A Report on Some North American Arctic and Subarctic Ichneumoninae

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The following contribution to our knowledge of the Ichneumoninae of the boreal parts of Canada and of Alaska is based mainly on material obtained by the Northern Insect Survey, which is a co-operative project of the Canada Department of Agriculture and the Defence Research Board, Canada Department of National Defence.

The contribution brings forward 12 new species and subspecies 3 of them being represented by both sexes, 9 by the female sex only. Some arctic species already named before or regarded as holarctic elements will be treated in a separate publication.

In the Ichneumoninae, especially in the genus Ichneumon L. the female sex presents structural specific differentiations in the shape of mandibles, antennae, cheeks, temples, tarsi and coxae III which all are absent in the male sex. Thus in this group of insects a species diagnosis can be efficient and fully useful only if based on the female sex, a fact which unfortunately was not well understood by many of the former authors. Furthermore, in the majority of cases it is impossible to associate the males correctly with their females on morphological characters. Such associations are usually not more than guess-work until confirmed and proven by biological facts such as observation of copula or rearing of both sexes from the same host. Future efforts, especially in the latter direction, would be of great value and constitute the only satisfactory method of establishing the taxonomic status of Arctic Ichneumoninae.

Genus *Eutanyacra* Cam.
1903, Trans. Ent. Soc. London p. 227
Generotype: *Eut. pallidicoxis* Cam. ♂ (Khasia Hills, India)

I examined the generotype specimen many years ago. Morphologically it is mainly characterized by a long narrow process in the middle of the hypopygium. This formation corresponds with *Spilichneumon* Thoms. and *Triptognathus* Wesm. The genotype of *Eutanyacra* Cam. differs from the former genus by its more abbreviated propodeum and especially by the abbreviation of the last 3 tergites; mainly the 7th, which is truncated and transverse thus giving a blunt shape to the apex of the abdomen. From *Triptognathus* Wesm., *Eutanyacra* Cam. may be easily distinguished by its normal, not unidentate mandibles. On account of the males I always inclined to consider *Eutanyacra* Cam. as a distinct genus. I was however not able to separate the females from the collective genus *Amblyteles* auct. or *Pseudamblyteles* Ashm. sensu meo; until recently when Dr. Townes drew my attention to the fact that the females of this group bear a bunch or fringe of long stiff bristles on the middle of the apical part of the hypopygium. This character indeed renders possible a clear separation from *Spilichneumon* females. It seems not quite so satisfactory for distinction from *Pseudamblyteles* Ashm. females (European palliatorius-group), the hypopygium of which is also covered by stiff bristles which, however, as a rule are shorter and more evenly distributed over the whole sternite. *Eutanyacra* females are furthermore recog-

nizable by the comparatively stout abdomen, always slightly compressed towards the apex and by the rather short propodeum with subquadrate or transverse area superomedia.

Since *Eutanyacra* Cam. evidently designates a natural group of species, strongly characterized in the male sex, recognizable also in the female sex, I propose to introduce this genus into the taxonomy of the North American Ichneumoninae, separating it from the collective genus *Pseudamblyteles* Ashm.

The diagnosis of *Eutanyacra* Cam. in short is this:

♀ ♂

Mandibles normal, upper tooth somewhat longer than lower, often blunt. Propodeum short, the area superomedia being subquadrate or more often transverse.

Male

Hypopygium with acute process in the middle length variable but sometimes considerable. Apex of abdomen of blunt appearance, the last tergites, especially the 7th, being more or less abbreviated, truncated and transverse. Thyloides tending to be parallel-sided, narrow, reaching from base to apex of flagellar joints.

Hypopygium with a bunch or fringe of long, stiff bristles covering the middle of the apical part. Abdomen short, slightly compressed towards apex, last tergites short. Legs stout. Temples and cheek usually broad.

The genus is represented in Europe only by one species as far as I know (*glaucatorius* Wesm.), in the oriental region by several species including the genotype, in North America by a fair number of species including primarily the *succinctus* group and *improvisus* Cress.

Eutanyacra chillcotti spec. nov. ♀ ♂

Type locality:—Salmita Mines (64°05′N, 111°15′W), Northwest Territory, Canada.

Holotype:— ♀, 4.VII.53, J. G. Chillcott, C.N.C. No. 6395.

Allotype:— ♂, Frobisher Bay, Baffin Island, N.W.T., Canada, 10.VII.48, T. N. Freeman.

A striking, tricolored species.

Female:—Head including antennae uniformly black, only a little spot at the top of eye-margins white. Thorax black with white marks. White: Scutellum, broad upper margin of pronotum, squamulae, two convergent short lines on the hind half of mesonotum, a short line on each side of mesonotum beside tegulae. Abdomen tricolored: 1st segment, last 3 sternites and tergites 3-7 black, the last tergites all with broad, regular white bands at the apex.—2nd tergite, narrow sides of tergite 3 and the rest of sternites bright orange-red. Legs red with black coxae, trochanters and femora II and III, coxae II and III with a white mark above. Length 10.5 mm.

Male

2nd and 3rd tergite entirely orange-red, tergites 4-7 regularly white-banded at the apex. White marks of head and thorax reduced to scutellum, squamulae and an indistinct short line on upper margin of prontoum. Legs as in the female. Length 12 mm.

Female

Head transverse, temples broad, rounded. Cheeks broad, swollen. Middle field of face distinctly, side fields slightly convex.

Mandibles normal, the upper tooth not very much longer than the lower.

Flagellum with 38 stout joints, short, sharply pointed, 1st joint seen from above not longer than wide at the apex, the second almost transverse, the broadest little broader than long, the last 4 joints distinctly longer than broad.

Scutellum flat, hardly raised above postscutellum.

Propodeum abbreviated, the sloping part about twice as long as the horizontal in the middle.   Area supermedia broader than long.

Postpetiole broad with distinctly defined, longitudinally striated, middle area.

Gastrocoeli triangular, fairly shallow, the interval little broader than one.

Abdomen rather short, slightly compressed towards the apex.   Sternites 1-3 with plica. Hypopygium with a dense fringe of long, stiff bristles.

Legs short and stout, Femora III only 2.65 times longer than wide in the middle.

Male

Thyloides on joint 1-13 of flagellum in shape of narrow parallel sided ridges over the whole length of the joints.

Hypopygium with a comparatively short but acute process in the middle.

Ichneumon masoni spec. nov. ♀

Type locality:—Cold Bay, 163W, Alaska.

Holotype:— ♀ , W. R. Mason, 25.VII.52, C.N.C. No. 6396.

A striking coloured species, probably related to *subdolus* Cress. but doubtlessly distinct.

Female:—Head and antennae uniformly red, the latter with indication of a yellowish annulus and black apex.   Thorax and coxae (not trochanters) black, scutellum white; mesonotum, tegulae squamulae, broad upper margin of pronotum, collare and a longitudinal band in the upper half of mesopleurae light red.   Abdomen bright red except base of petiole. Tergites 2-5 with broad, regular ivory-yellow apical bands, the one of the 5th broadened in the middle; tergites 6 and 7 with broad apical marks of the same colour. Legs including trochanters light red; all tibiae with a yellowish area beyond the base.   Length 13.5 mm.

Head transverse, temples little narrowed behind the eyes, cheek profile in front view very little narrowed towards mandibles.

Mandibles broad, upper tooth not much longer than lower.

Flagellum stout, filiforme, inconspicuously broadened and on one side flattened beyond middle; not attentuated towards apex; with 36 joints; first joint 1.45 times longer than broad at the apex; seen from the side the 4th joint as long as broad; joints towards the apex of flagellum distinctly transverse.

Mesonotum distinctly longer than broad in the middle.

Scutellum flat, somewhat raised above postscutellum.

Area supermedia subquadrate.

Postpetiole with clearly defined, longitudinally striated middle field.

Gastrocoeli shallow, triangular, their interval about as wide as one of them.

Abdomen fairly broad and blunt.

Coxae III densely and strongly punctured; without any brush.

Ichneumon byrdiae spec. nov. ♀ ♂

Type locality:—Spence Bay, Northwest Territory, Canada.

Holotype:— ♀ , J. G. Chillcott, 21.VII.51, C.N.C. No. 6397.

Allotype:— ♂ , Frobisher Bay, Baffin Island, F. G. Dilabio, 5.VII.48 in Canadian National Collection.

Paratypes:—1 ♀ , Herschell Island, Yukon Territory, F. Johannsen, 30.VII.16; 1 ♂ , Repulse Bay, Northwest Territory, Canada, J. E. H. Martin, ex *Byrdia rossi*, larva coll. 28.VI.50.   Paratypes in Canadian National Collection.

Host:—*Byrdia rossi* Curt. (Holotype and 1 ♂ paratype).

Female:—Biggest of the known arctic species of the genus.   Black with the legs (except coxae and trochanters), mesonotum, scutellum, postscutellum, upper

margin of pronotum, collare, squamulae, upper part of mesopleurae and some-
times the propleurae (specimen from Yukon Territory) dark red. First segment
of the same colour. Second tergite dark red in variable extent: in the holotype
black only towards the hind margin, in the specimen from Repulse Bay with red
sides. Head black without red marks. Antennae black in the holotype with
the 5 basal joints of flagellum and the scape dark red. Length 15 mm. (paratype
13.5 mm.)

Male:—Only the following parts dark red: scutellum, postscutellum and legs
(except coxae and trochanters). In the specimen from Repulse Bay postpetiole
and sides of 2nd tergites with a dark reddish tint. Length 15 mm.

Female

Ha transverse covered by long, fuscous hair, strongly irregularly punctured
(except lower part of cheeks), frons irregularly reticulate-punctured, temples
roundly and not strongly narrowed behind the eyes, cheeks profile considerably
narrowed towards mandibles. Middle field of face strongly convex.

Mandibles; upper tooth acute and considerably longer than the somewhat
reduced lower tooth.

Flagellum with 41-43 joints, slender, of medium length, lightly broadened
and distinctly flattened at one side beyond the middle, then attenuated and sharply
pointed, the first joint being about 2 times longer than broad at the apex, about the
8th joint square, the broadest joint being only slightly broader than long.

Mesonotum densely punctured and haired. Scutellum fairly flat above,
truncated at the end and highly elevated above the post-scutellum.

Mesopleurae considerably swollen and protruding behind the epicnemiae.

Propodeum very short, the area superomedia being more than twice as broad
as long in the holotype.

Postpetiole exceptionally broad in the holotype, fairly broad in the paratype,
the middle area rather clearly defined and longitudinally striated.

Abdomen broad, the second tergite considerably broader than long, the
third at least three times broader than long. Gastrocoeli transverse, their interval
about equal in width to one of them.

Coxae III densely punctured, more finely on the inner, strongly on the outer
side, covered by long, fuscous hair but without brush.

Mesonotum strongly and densely punctured.

Male,

Thyloides on joint 7-16 of flagellum only, longish oval, the longest neither
reaching to the base nor to the apex of the joint.

Scutellum strongly and much more raised above the post-scutellum than in
the female.

Ichneumon byrdiops spec. nov. ♀

Type locality:—Seward, Alaska.

Holotype:— ♀, W. J. Brown, 12.V.1951, C.N.C. No. 6398.

Paratype:— ♀, from type locality, W. J. Brown, 15.VI.1951.

This species shows considerable convergency in colour with *I. byrdiae*
Heinr. It is very distinctly different in shape of flagellum and mandibles.

Female

Black:—2nd tergite and sides of 3rd (holotype) or 2nd and 3rd tergite (para-
type) dark red. Scutellum more or less obscure red. Legs including trochantelli
clear red. Flagellum black. Wings smoky. Length 13 mm.

Head and thorax covered by long hair. The former transverse, temple
profile rounded, little narrowed behind eyes, cheek profile somewhat narrowed

towards mandibles. The latter with a strong, long upper tooth and a much shorter, almost obsolete lower.

Flagellum stout, rather short, nearly filiform, a bit broadened and distinctly flattened below beyond middle and slightly tapering at the apex with 40-41 joints, first joint 1.35 times longer than broad at the apex, seen from the side the 5th or 6th joint as broad as long, the broadest seen from the flat side about 1⅓ times broader than long.

Mesonotum densely haired with shallow, not dense puncturation. Notauli indistinctly indicated at the very base. Scutellum weakly convex, hardly raised above postscutellum.

Area superomedia slightly transverse.

Postpetiole with fairly distinct middle field which is (in both specimens) irregularly transversely striated.

Gastrocoeli relatively small, triangular, the interval much broader than one.

Coxae III rather densely punctured without trace of scopula.

Ichneumon amauropus spec. nov. ♀

Type locality:—Alert, Ellesmere Island (between 82° and 83°N!) Northwest Territory, Canada.

Holotype:— ♀, summer 1951, C.N.C. No. 6403.

Female

A red species very distinctly characterized by its unusually long, straight, strongly narrowed cheek profile (reminiscent of the genus *Hoplismenus*), the slender, gradually attenuated though not very sharply pointed flagellum, the transverse gastrocoeli with narrowed interval, the distinctly striated postpetiole and the area superomedia being not transverse.

Red:—Only the following black: sterna, the black colour extending from the mesosternum up onto the lower part of mesopleura, metapleura partially, epicnemial field, coxae and trochanters below, clypeus and a vertical band on each side of the middle field of the face joining below the black of clypeus and a stripe on the outer orbits below. Flagellum blackish brown. Wings evenly infuscated. Length 10 mm.

Head transverse, vertex sloping down from the hind margin of eyes and ocelli, temple profile roundly and not strongly narrowed behind eyes, cheek profile strongly narrowed in a straight line towards mandibles, the malar space being considerably longer than the width of mandibles base. Middle field of face strongly, clypeus, slightly convex.

Mandibles normal, upper tooth little longer than lower.

Flagellum with 32 joints, slender, hardly broadened beyond middle but distinctly flattened beneath, gradually attenuated towards the end though not very sharply pointed at the apex, the first joint being approximately twice as long as wide at the apex, about the 7th joint as long as wide, the broadest joint seen from the flat side subquadrate.

Mesonotum and even the scutellum densely and rather strongly punctured all over, the latter considerably elevated above postscutellum and gradually sloping down to the latter at the end.

Area superomedia not transverse as in *lariae* Curt. but as long as wide in the middle, its sides a little convergent toward base.

Postpetiole with distinct, longitudinally striated middle field.

Gastrocoeli transverse, their interval somewhat narrower than one.

Tergites 2 and 3 densely and rather strongly punctured, not much shining.

Coxae III densely punctured all over, without scopula.

Tarsi III especially the metatarsus, long and slender, tarsi I somewhat abbreviated.

Key for the *Ichneumon* species of boreal Canada with basic black colour of the whole body and red legs

♀ ♀

1. Antennae slender, strongly attenuated (tarsi III blackish).. 2

    Antennae filiform, not strongly attenuated but sometimes a little pointed at the very apex (tarsi III usually red, seldom blackish)... 3

2. Scutellum black, flagellum without distinct annulus (Western Yukon Territory)
    cessatorops sp. nov.

    Scutellum entirely white, flagellum with broad whilte annulus (Quebec)
    cessatorops kazubazuae ssp. nov.

3. Scutellum, whole upper margin of pronotum, inner orbit, and large marks on tergites 5-7 white. (Antennae stout with short joints. No scopula. Area superomedia longer than wide) (Ft. Chimo, Quebec)......................................*gavisicolor* spec. nov.

    No white marks on head, thorax, and 5th tergite.. 4

4. Scutellum and postscutellum yellowish red. Middle field of postpetiole not sharply defined and with fine, irregular, sometimes obsolete aciculation. (Tergites 1 and 2 with shallow punctures which are separated by at least the length of their diameter or more. Flagellum slender, neither broadened nor pointed at apex. Head and thorax with long hair) (Labrador)...*perretti* sp. nov.

    Scutellum and postscutellum black, rarely the former with an irregular obscure reddish mark. Middle field of postpetiole sharply separated from the sides, almost always sharply aciculated.. 5

5. Disc of 2nd tergite with shallow punctures separated in average by several times their own diameter. Flagellum stout and thick, first joint being only 1.2 times longer than wide at the apex. (End of abdomen blunt, ovipositor almost hidden) (Labrador)...*nebularum* sp. nov.

    Disc of 2nd tergite much stronger and denser punctured. Flagellum more elongated, first joint longer compared with width. (Ovipositor distinctly extending beyond last tergite).. 6

6. Area superomedia longer than wide. Tibiae III, 5.4 times longer than wide at the apex seen from the side view. Tergites 6 & 7 narrowly white marked. (Notauli obsolete. Coxae III, with rather distinct scopula) (Northwest Territory, Manitoba)
    trigemellus spec. nov.

    Area superomedia usually transverse, sometimes subquadrate. Tibiae III, 6.1 times longer than wide at apex. Last tergites usually black. Exceptionally 7th tergite with an indistinct white mark. (Notauli distinct at base or obsolete. Coxae III, with ± distinct scopula) (Colorado, Alberta, Manitoba, Newfoundland)......*artemis* Viereck

Ichneumon perretti ,spec. nov. ♀

Type locality:—Hopedale, Labrador.

Holotype:— ♀ , W. W. Perrett, 31.VII.26, C.N.C. No. 6399.

Paratypes:—29 ♀ ♀ , from type locality, W. W. Perrett, 1924-1928. In Canadian National Collection, Ottawa and in collection G. H. Heinrich, Dryden, Maine.

Female

Black.—Legs red. Always reddish or yellowish red are: scutellum, postscutellum, tegulae, apex of dorsal margin of pronotum, collare, coxae I, base of flagellum. Apex of clypeus and middle of face usually reddish. Coxae II and III, usually partially, sometimes entirely black. Flagellum dark towards apex. Length 11-12 mm.

Variability (based on 30 specimens):

Mesonotum with a dark red mark in the middle.. 4
Mesonotum with two dark red stripes in the middle............................... 1
Tergites 5-6-7 indistinctly dark reddish... 8
Tergite 7 with a white spot... 1

Female

Head transverse strongly irregularly punctured except cheeks and with fairly long reddish hair. Temples and cheeks broad, the former hardly narrowed behind eyes, cheek profile only slightly narrowed towards mandibles. Middle field of face elevated. Mandibles normal, the upper tooth being somewhat longer than the lower.

Flagellum with 40-41 joints, filiform, slender, fairly long and of even width throughout, neither broadened beyond the middle nor attenuated at the apex, inconspicuously flattened on one side towards the end, the first joint being 1⅓ times longer than broad at the apex, seen from the side about the 7th joint as long as broad, about the last 10 joints transverse.

Mesonotum shining, strongly and rather densely punctured. Scutellum slightly convex. No trace of notauli.

Pleura and sterna with long, reddish hair.

Propodeum rather short with the area superomedia subquadrate or slightly transverse.

Postpetiole with rather distinct though not clearly defined middle field, the latter usually with fine, more or less irregular sometimes indistinct, striation; sometimes smooth.

Gastrocoeli triangular, transverse, their interval distinctly broader than one.

Abdomen longish, 2nd and 3rd tergites with shallow but distinct puncturation and fine, coriaceous, undersculpture between punctures.

Coxae III, strongly and fairly densely punctured, less strongly and more densely punctured on the inner side where, at the apex, punctures are running into transverse striae; hairy but without scopa.

Ichneumon nebularum spec. nov. ♀

Type locality:—Hopedale, Labrador.

Holotype:— ♀ , W. W. Perrett, 31.VII.26, C.N.C. No. 6400.

Paratypes:—12 ♀ ♀ , from type locality, W. W. Perrett, 1924-1928. In Canadian National Collection, Ottawa and in collection G. H. Heinrich, Dryden, Maine.

A very distinct, big black species with red legs easily identified by morphology of flagellum and postpetiole. Considerably bigger than *I. perretti* occurring in the same locality.

Female

Deep black all over including scutellum, coxae and trochanters. Legs including trochantelli red. Collare sometimes obscure reddish. Flagellum black: underneath at the middle and beyond the middle, and the basal joints at the apex, usually more or less distinctly reddish brown.

Head seen from above wider compared with its longitudinal diameter than in *I. perretti* Heinr. Otherwise similarly built to the above-mentioned species and similarly sculptured and haired.

Mandibles normal.

Flagellum with 38 joints, filiform but somewhat narrowed towards the apex; stout, thick, distinctly broadened and flattened beneath beyond the middle; first joint 1.2 times longer than broad at the apex, about 4th joint seen from the side as long as broad, broadest joint 1½ times broader than long.

Mesonotum rather strongly punctured, glossy. Notauli distinct at the base (absent in *perretti*). Scutellum with rather flat, glossy, sparsely punctured surface, considerably raised above postscutellum.

Pleura and sterna with long, reddish hair.

Propodeum short. Area superomedia transverse, sometimes more than 1½ times broader than long.

Postpetiole very broad with clearly defined strongly aciculated, middle field which is sharply separated and elevated at the knee. Exceptionally (1 specimen) striation obsolete.

Gastrocoeli triangular, transverse, their interval about as wide as one.

Abdomen longish, 2nd and 3rd tergites with shallow but distinct puncturation and fine coriaceous undersculpture between punctures. Distance of the latter averaging several times bigger than diameter of one. Apex of abdomen fairly blunt, ovipositor almost entirely hidden.

Coxae III densely and strongly, at the inner side more finely punctured, hairy but without scopa.

Ichneumon trigemellus spec. nov. ♀

Type locality:—Norman Wells, Northwest Territory, Canada.

Holotype:— ♀, C. D. Bird, 25.V.1953, C.N.C. No. 6402.

Paratypes:—Gillam, Manitoba, Canada, J. F. McAlpine, 11.VI.1950, in collection Gerd H. Heinrich, Dryden, Maine.

Female

Deep black including scutellum, coxae and trochanters. Legs including trochantelli yellowish red. Inner orbits up to the vertex and down to the level of base of antennae narrowly yellowish red. Flagellum blackish brown in the holotype with slight indication of a lighter annulus beyond middle and blackish apex; reddish below. Length 13 mm.

Extremely similar to *I. artemis* Viereck. Differing from the latter by:

1) the shape of area superomedia which tends to be longer than wide.

2) stouter tibiae III which are only 5.4 times longer than wide at the apex (seen from the side).

3) presence of a distinct longitudinal mark on tergite 7 and a smaller one on tergite 6.

Flagellum with 42 joints, filiform, long, slender, not broadened and only slightly flattened beneath beyond middle, very little attenuated at apex, first joint 1.8 to 2 times longer than broad at the apex, seen from the side about 9th joint as long as wide at the apex, about 12 joints counted back from the apex of flagellum transverse.

Notauli obsolete even at extreme base.'

Otherwise like *artemis* Viereck.

Ichneumon cessatorops spec. nov. ♀

Type locality:—Watson Lake, Yukon Territory, Canada.

Holotype:— ♀, W. R. Mason, 23.VI.1948, C.N.C. No. 6404.

Female

In general appearance and especially in the sharply attenuated, long and slender flagellum this species approaches the European *I. cessator* Müll. In the latter species however the flagellum is still more slender and the scutellum is still more strongly elevated above postscutellum. Nevertheless *cessatorops* Heinr. might perhaps represent the nearctic vicarious form of *cessator* Müll. From all similarly coloured species of boreal America *cessatorops* Heinr. differs by the mentioned shape of the flagellum.

Deep black including scutellum, coxae and trochanters. Legs red including trochantelli. Apex of tibiae III blackish, tarsi III brownish. Narrow inner orbits of frons yellowish red. Narrow apical edge of tergites 2 and 3 reddish. Anten-

nae blackish, obscurely brownish beneath and around apices of basal joints of flagellum, with indistinct indication of a lighter annulus on joints 9-11. Length 14 mm.

Head transverse, temple profile considerably narrowed behind eyes, cheek profile the same towards mandibles, straight. Cheeks not swollen. Malar space longer than width of mandible base. Occiput sloping down immediately from hind margin of eyes and ocelli. Upper mandible tooth acute and considerably longer than lower.

Flagellum with 42 joints, attenuated, long, slender, distinctly though not strongly broadened beyond middle and simultaneously strongly flattened beneath, then tapering gradually into the acute apex, first joint twice as long as wide at the apex, seen from the side about the 10th joint as long as broad, seen from the flat side the broadest joint about 1.3 times broader than long, last 3-4 joints longer than wide.

Mesonotum rather strongly and densely punctured. Notauli slightly indicated at the base. Scutellum strongly elevated above postscutellum.

Area superomedia strongly transverse, about 1½ times broader than long.

Postpetiole with clearly defined, strongly striated middle field.

Abdomen longish, sharply pointed at the apex, the ovipositor distinctly projecting beyond last tergite. Second and third tergites strongly and densely punctured, punctures running into striae at base of second.

Gastrocoeli transverse, triangular, the interval distinctly broader than one.

Coxae III strongly and densely punctured all over without trace of scopula.

Ichneumon cessatorops Heinr.
Kazubazuae ssp. nov. ♀

Type locality:—Kazubazua, Quebec, Canada.

Holotype:— ♀, F. A. Urquhart, 7.VI.37, C.N.C. No. 6405.

Agrees in morphology and sculptures exactly with *cessatorops cessatorops*, but differs in colour by the entirely white scutellum; the broad, white annulus of flagellum and the greater extent of yellowish red colour on inner orbits.

Second and third tergites with some obscure reddish tint on the discs.

Ichneumon gavisicolor spec. nov. ♀

Type locality:—Ft. Chimo, Quebec, Canada.

Holotype:— ♀, R. H. MacLeod, 18.VI.1948, C.N.C. No. 6406.

A species distinctly characterised by its colour pattern and proportions of flagellum.

Black, flagellum, head and thorax white marked. Tergites 5-7 with conspicuous white marks. White are: the whole scutellum, squamulae, the entire broad upper margin of pronotum, collare, broad inner orbits from the upper part of face up to the top of vertex. Legs red, including trochantelli. Antennae black with broad, white annulus. Length 13 mm.

Head transverse, temple profile roundly and distinctly narrowed behind eyes, cheek profile considerably narrowed towards base of mandibles. The latter normal, the upper tooth a little prolonged.

Flagellum with 39 joints, stout and rather short, filiform, hardly attenuated at the apex, distinctly broadened and flattened beneath beyond the middle, 1st joint 1.3 times longer than wide at the apex, 4th joint seen from the side as long as wide, the broadest joint seen from the flat side almost twice as wide as long, all following joints except the end-cone transverse, joint 8-13 with white annulus.

Mesonotum rather strongly and densely punctured, shiny, without trace of notauli.   Scutellum flat above, slightly raised above postscutellum.

Area superomedia longer than wide.

Postpetiole with clearly defined and distinctly aciculated middle field.

Gastrocoeli triangular, the interval little broader than one.

Abdomen sharply pointed at apex, the ovipositor extending distinctly beyond last tergite.   Tergites 2 and 3 densely and strongly punctured, the punctures running into striae in the middle of 2nd tergite.

Coxae III strongly and densely punctured all over, shiny, sparsely hairy, without trace of scopula.

Ichneumon artemis Viereck ♀

Origin:—*Cratichneumon artemis* Viereck, Ent. News 13, p. 87, March 1902.
Type locality:—Colorado.
Holotype:—Collection Am. Ent. Society, Philadelphia.

A specimen from Waterton Lake, Alberta was compared with the type by W. R. Mason and stated to be specifically identical.   This specimen has dark tarsi III and no light mark on the inner orbits.

The Canadian National Collection contains about 12 further specimens differing but very little from the one mentioned above collected on different localities widely spread over the northern parts of Canada.   Most of them have the tarsi III coloured yellowish red like the rest of the legs and the inner orbits marked with a reddish line.   But there are also a few specimens represented with dark tarsi III and orbits, one of these from as far northeast as Labrador.

There are some very small morphological differences between the Canadian specimens especially in the degree of development of notaulics.   I was unable however to find characters distinct enough for proving specific differences though I suspected the existence of the latter.   The final solution of the problem has to be delayed until further material and information is available.

Patroclus walleyi spec. nov. ♀ ♂

Type locality:—Smoky Falls, Mattagami River, Ontario, Canada.
Holotype:— ♀ , G. S. Walley, 16.VI.1934, C.N.C. No. 6407.
Allotype:— ♂ , from type locality, G. S. Walley, 8.VII.1934, in Canadian National Collection, Ottawa.
Paratypes:—2 ♀ ♀ , Norman Wells, Northwest Territory, 17.VI and 21.VII. 1949, S. D. Hicks, and W. R. M. Mason; 1 ♀ , Fort Smith, Northwest Territory, 27.V.1950, W. S. Helps; 1 ♀ , Ogoki, Ontario, 26.VI.1952, J. B. Wallis; 1 ♂ , Norman Wells, Northwest Territory, 30.VII.1949, W. R. M. Mason in Canadian National Collection, Ottawa; 1 ♀ , from type locality, G. S. Walley, 12.VI.1934 in collection Gerd H. Heinrich, Dryden, Maine.

A distinct species reminiscent in colour pattern somewhat of the European *sputator* F.   Differing from the latter by the very densely and strongly punctured, opaque mesonotum and the more narrowed, longer cheeks.

Female

Black.—Tergites 2-3 reddish yellow.   All tibiae and tarsi and the knees I and II of the same colour.   Antennae with a broad yellowish annulus on joints 3 or 4 or 5 to 11 or 12.   Length 15-16 mm.

Male

Tegulae and squamulae yellow.   Scape with a light spot beneath, in one specimen base of flagellum obscure reddish.   Yellow colour of legs lighter and more extended: femora I entirely yellow, besides knees II also knees III yellowish. Light colour of tergites 2 and 3 somewhat darkened at the narrow apex and

sometimes base. In one specimen apex of postpetiole yellow. No annulus. Otherwise like female. Length 16 mm.

Female

Temple profile narrowed in straight line behind eyes, cheek profile strongly and in a straight line narrowed towards mandibles. The latter normal, the upper tooth but little longer than the lower.

Flagellum long, slender, strongly attenuated, with 40 joints, not broadened but distinctly flattened below beyond middle, first joint 2.7 times longer than wide at the apex, seen from the side about 12th joint as long as broad, the broadest joint seen from the flat side about as broad as long.

Mesonotum very densely and strongly punctured, opaque. Scutellum short, abruptly and deeply sloping down to the postscutellum.

Area superomedia great, subquadrate.

Postpetiole with sharply defined aciculated middle field, at the knee raised.

Note on *Mediolata mali* (Ewing) (Acarina: Raphignatidae) as a Predator of the European Red Mite[1]

By B. PARENT[2] AND E. J. LeRoux[3]
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Early in July, 1953, a yellowish mite was observed feeding on active forms of the European red mite, *Metatetranychus ulmi* (Koch), in an orchard at Rougemont, Qué., where a minimum of pesticides (insecticides and acaricides) detrimental to the natural fauna had been used for two years. The mite increased considerably in numbers during 1954 and 1955, contributing noticeably to the control of the European red mite.

Specimens were identified by Dr. H. H. J. Nesbitt, Carleton College, Ottawa, as of *Mediolata mali* (Ewing).

According to Baker and Wharton (1952), members of the family Raphignatidae, although distributed throughout the world, are not very well known. *M. mali* was described as *Syncaligus* (*Caligonus*) *mali* by Ewing (1917) and reported as a pest of apple in Hillboro, Oregon, in 1913. Garman (1948) collected this mite from apple leaves in Connecticut but did not state whether he considered it destructive or beneficial. Groves (1951) makes no mention of *M. mali* in her world synopsis of the literature on *M. ulmi*.

This is apparently the first record of *M. mali* as a predator of *M. ulmi* in Canada.

References

Baker, E., and C. W. Wharton. 1952. An introduction to acarology. The Macmillan Co., New York.

Ewing, H. E. 1917. New species of economic mites. *J. Econ. Ent.* 10: 497-501.

Garman, P. 1948. Mite species from apple trees in Connecticut. *Connecticut Agr. Expt. Sta. Bull.* 520.

Groves, J. R. 1951. A synopsis of the world literature on the fruit tree red spider mite, *Metatetranychus ulmi* (Koch), and its predators. Commonwealth Inst. Ent., 41 Queen's Gate, London, S.W. 7.

The Red Pine Web-spinning Sawfly, *Cephalcia marginata* Middlekauff (Hymenoptera, Pamphiliidae)[1]

By Lionel Daviault
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This insect was first noticed during the summer of 1939 in a young red pine plantation in the vicinity of Berthierville, Que. A large number of mature larvae were collected at the end of the same season and placed on the foliage of small red pine trees enclosed in wire cages in the field. The larvae soon left the trees to enter the soil for overwintering. The following spring, numerous adults emerged in the cages, and in order to obtain an identification, several specimens were sent to Dr. O. Peck, Entomology Division, Ottawa, who considered that this was apparently a new species of the genus *Cephalcia*. Later, many specimens were sent to Dr. W. W. Middlekauff, of the University of California, who described the species under the name *C. marginata* (1953).

Since its discovery, the insect has been found in a few other plantations in the neighbourhood of Berthierville, but no attempt was made to determine its exact distribution. Thus far, the insect has been found only on young red pines and never abundant enough to cause serious damage.

All data reported in this paper were obtained during rearings of the insect in Berthierville. Since a rather complete study on egg, larva, and adult morphology of this insect has been published by Mr. I. Rivard (1955), only brief descriptions of its different stages will be given.

Description and Habits

The insect produces only one generation annually. The life cycle starts with the appearance of the adults in the spring. In 1940, 320 adults emerged in our cages in the field. The first specimens appeared on May 29 and their numbers gradually increased until a peak was reached on June 6, then decreased until the last specimens emerged on June 14. The males were slightly more abundant than the females: 171 males to 149 females. However, examination of many adults obtained from different sources seems to indicate that both sexes are produced in equal numbers.

The adult is characterized by its general robust appearance, its long filiform antennae and its almost black colour, with a few yellowish spots distributed on the head and body. The female (Fig. 1) is easily distinguished from the male (Fig. 2) by the presence of ivory-yellowish narrow lines on the apical margin of the abdominal segments 3 to 6, and by a lightly infuscated band on the apices of the wings.

Although the adult is very active, it is a moderate flyer, and this perhaps explains why the insect spreads so slowly to new areas. The life span of the adult is relatively long. In 1940, in a lot comprising 21 males and 25 females confined in a wire-screened cage in the insectary of temperatures ranging from 62°F. to 65.4°F., males lived from 2 to 10 days with a mean duration of 5.5, and females from 5 to 12 days, with an average of 8.0 days.

Mating was frequently observed but unfertilized females also oviposited readily and their eggs developed in the normal manner. There was no difference in the rate of oviposition between fertilized and unfertilized females.

Females can start laying their eggs on the day of emergence, although they often wait until the next day and in some cases the period may be extended to 5 days. The oviposition period extends from 8 to 10 days, with numerous
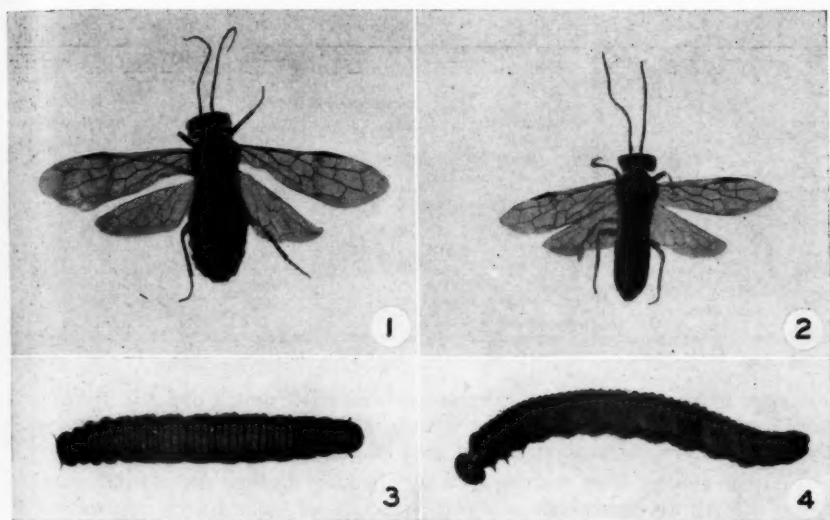
Fig. 1. *Cephalcia marginata*, female.
Fig. 2. male.
Figs. 3 and 4. larva.

resting days between layings. For instance, one female emerged on June 10, 1940, deposited 4 eggs the same day, 5 the following day, 7 on June 13, and 3 on June 16, making a total of 19 eggs laid on 4 separate days over an oviposition period of 7 days.

Eggs are laid on the needles of the preceding year's growth. When about to oviposit, the female crawls on to the upper surface of a needle and places her body at right angles to the axis of the needle. It then moves its abdomen slowly from right to left for a certain time and finally, a droplet of black liquid appears at the end of the ovipositor and falls off on the surface of the needle. The female then bends the tip of its abdomen and the egg appears between the blades of the saw sheath, and gradually is pushed out as the insect lifts up its abdomen. Helping itself with the tip of its abdomen, the female then coats with some fluid the exposed surface of the egg. The whole operation takes about 30 seconds and after the first egg has been laid, the female walks away, rests for a while and repeats the same operation. Eggs are laid at the rate of one every 10 minutes.

The eggs are laid continuously in single rows of 4 to 15, and one female may deposit a total of three or four such lots, each lot being on a separate needle. The largest number of eggs deposited by any one female in our cages was 49 and the average egg production per fertilized female for 20 females was 24.

Although in nature the insect shows a decided preference for red pine, females caged with white spruce trees in the field readily oviposited, but never more than three eggs per needle. This is easily explained by the fact that the female experiences some difficulty in keeping its balance on these needles, which are about the same length as its own body.

Eggs are elongate, sub-cylindrical in outline, with rounded ends. The surface is smooth, whitish, and shining when freshly laid. As incubation proceeds, the colour of the egg becomes a cloudy green. The average size of

TABLE I

Duration of incubation period in days

Year	Number of eggs	Incubation period		Mean temp. during period in degrees F.
		Average	Range	
1940.	579	26.1	21–31	60.5
1941.	262	24.5	20–27	61.6
1942.	61	20.2	18–21	62.1
1943.	37	25.5	23–26	62.3

205 eggs measured under the microscope was 2.315 mm. (1.94-2.52 mm.) and 0.967 mm. (.66-1.14 mm.). The period of incubation did not vary much during the four years of observation, as indicated in Table 1.

Larvae emerge from the egg shell by chewing through the chorion without eating it. All the individuals hatching from one lot move to the intersection of two small branches. They immediately start to eat the needles while spinning a loose web about them. With the accumulation of grass and debris the nest enlarges progressively and becomes a more or less egg-shaped mass (Fig. 5). On the average, nests measure 5 cm. by 2 cm. and contain 12 to 15 larvae, although some nests collected measured close to 10 cm. by 3cm. and contained approximately 20 larvae.

Larval moulting takes place within the nest, but in all old nests examined, only cast head capsules were found, the remainder of the cast skins probably having been eaten.
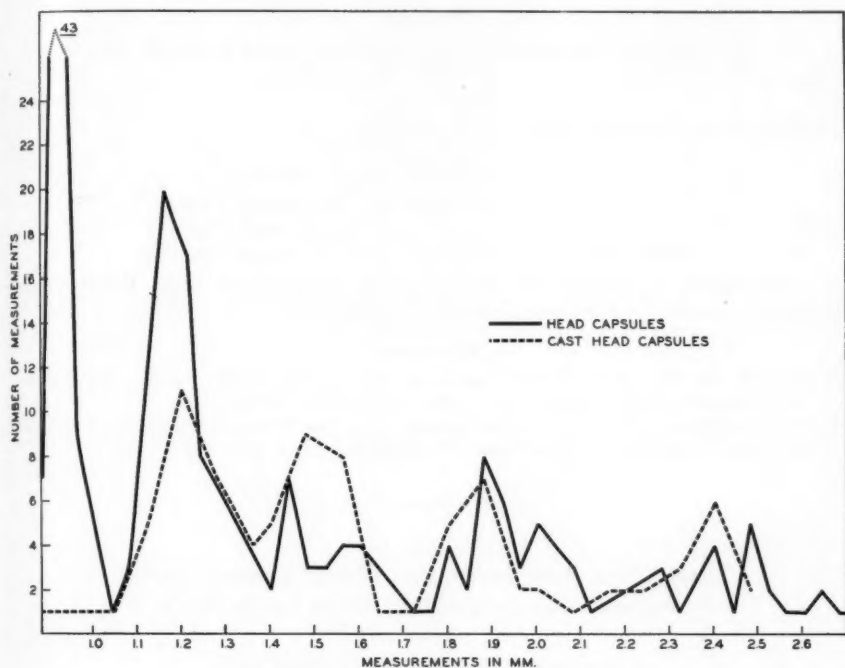

Fig. 5. *Cephalcia marginata*, nest of larvae.

Fig. 6. *Cephalcia marginata,* larval head-capsule measurements.

In order to ascertain the number of instars, head-width measurements were made of 225 larvae obtained from rearings or collected in the field at different periods during the summer. The results, shown in Fig. 6, indicate the five peaks which correspond to the five larval instars.

In the early instars, the body of the larva (Figs. 3 and 4) is of a greenish colour with a black head. When mature, the colour turns cream-white with the exception of the head, legs, sclerotized plates on the thorax, and the last abdominal segment, which are reddish-brown. Two small caudal horns are present on the last abdominal segment; antennae are relatively long; there are no abdominal prolegs. Length when full grown is about 27 mm., and width about 4 mm.

The length of the larval feeding period was not determined by direct observation, but considering that, in 1940, the maximum hatching of larvae occurred on June 18, and the majority of the larvae had completed their development and had left their nests by August 14, it can be calculated that the larvae can complete their development on the trees in approximately 57 days.

When fully grown, the larvae leave the foliage to enter the soil where they overwinter. Their colouring then changes and they become completely green.

Development is normally resumed the following spring and the larvae transform into pupae, then into adults. A certain proportion of the larvae remain in diapause, however, and this period may extend over three years at least; in a lot of larvae which entered the soil in the fall of 1939, 372 emerged in 1940, 29 in 1941, and 5 in 1942.

Parasites

In 1940, the following species of parasites were reared from this insect:

Diptera, Tachinidae:	*Zenillia fronto* (Coq.)
	Zenillia sp.
Hymenoptera, Ichneumonidae:	*Bathythrix* sp.
	Holocremnus sp.
	Homaspis albipes Davies
	Homaspis sp. near *nigripes* Cush.
	Xenoschesis cinctiventris (Ashm.)
Pteromalidae:	*Psychophagus ommivorus* (Wlkr.)

The author is indebted to the Systematic Entomology Unit, Entomology Division, Ottawa, for the identification of this material.

References

Middlekauff, W. W. 1953. A New Species of Web-spinning Sawfly Feeding Upon Pines (Hymenoptera, Pamphiliidae). Pan Pacific Entomologist, 29: 133-134.

Rivard, I. 1955. Contribution to the Morphology of a Pine Web-spinning Sawfly, *Cephalcia marginata* Middlekauff (Hymenoptera: Pamphiliidae). Can. Ent. 87: 382-400.

Three New Species of the Genus *Cinara* Curtis (Homoptera: Aphididae) from *Larix* SPP.[1]

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Cinara spiculosa n. sp.

Apterous viviparous female

General colour dark brown. Tibia with a short proximal portion, and distal ⅓, dark brown, remainder light yellowish-brown. Antenna light brown, except segments I and VI, distal ⅓ of V, and extreme tips of III and IV, which are dark brown. Dorsum of metathorax and abdomen thickly speckled with raised, subcircular spots, some of which are joined together to form raised areas of irregular shape (Fig. 1, A). Each dark spot bears a stout, spine-like seta. Many setae on the dorsum terminate in enlarged, bifurcate tips.

Measurements: Body length 2.99 mm., width 1.75. Width of head across eyes .73. Antenna, total length 1.17, segments, III .44; IV .18; V .23; VI .13 and .04. Hind tibia, length 1.74, diameter .09. Lengths of hind tarsal segments, I .11; II .27. Rostrum reaches third abdominal segment. Length of rostral segments, III .22; IV .15; V .08. Diameter of cornicle base .23. Length of setae, on antenna .05, on hind tibia .08, on dorsum of abdomen .09.

Sensoria: On antennal segments, III, 1; IV, 1; V, 2; VI, 7. Antennal VI with eleven basal and two secondary subapical setae (Fig. 1, E.).

Alate viviparous female

Setae of head and prothorax on raised, subcircular spots (Fig. 1, D). Colour as in apterae. Abdomen mainly clear, without conspicuous dark spots, and setal bases much smaller than in the apterous female.

Fig. 1. A, portion of dorsum of abdomen; B, hind tibia; C, hind tarsus; D, head; F, sixth antennal segment. A, B, C, K, L, M, N, apterous viviparous female; E, F, G, H, I, J, O, oviparous female; D, alate viviparous female; s.sa, secondary subapical setae; b, basal setae.

s. sa

b.

C. spiculosa   E

J   C. lyallii   O

C. subterranea
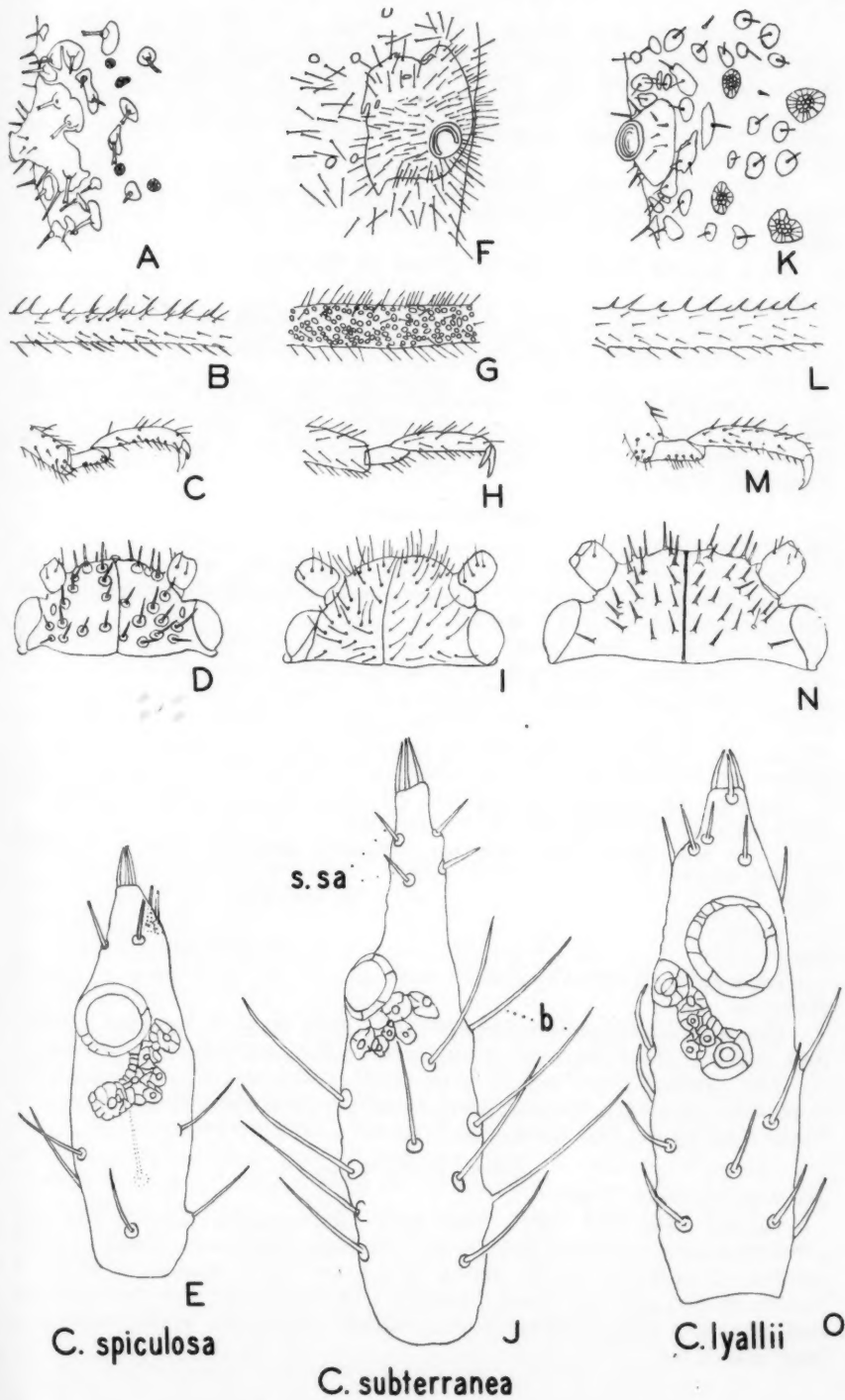
Measurements: Body length 2.74 mm., width 1.10. Width of head across eyes .65. Antenna, total length 1.13, length of segments, III .43; IV .18; V .22; VI .12 and .03. Hind tibia, length 1.45, diameter .07. Length of hind tarsal segments, I .09; II .23. Rostrum reaches middle of abdomen. Diameter of cornicle base .31. Length of setae, on antenna .04, on hind tibia .08, on dorsum of abdomen .10.

Sensoria: On antennal segments, III, 6; IV 2; V, 3; VI, 7. There are six basal and two secondary subapical setae on antennal VI (Fig. 1, E).

Host

Larix laricina (DuRoi) Koch. Found on the small twigs.

Holotype

Apterous viviparous female, collected at Deschambault Lake, Sask., June 24, 1955, by B. McLeod. Type deposited in the Canadian National Collection, Ottawa.

This species is strikingly similar to the European species C. *laricis* (Hartig) differing in having bifurcate, rather than acuminate setae. The writer is indebted to Dr. Hille Ris Lambers, Holland, for specimens of C. *laricis* and for his comments on the two species.

Cinara subterranea n. sp.

Oviparous female

General colour greyish-brown. Legs dark brown except for a short proximal portion of the femora. Antenna almost uniformly dark brown. Setae fine and numerous (Fig. 1, F and I).

Measurements: Body length 3.27 mm., width 1.85. Width of head across eyes .72. Antenna, total length 1.62, segments, III .55; IV .30; V .34; VI .17 and .06. Hind tibia, length 1.98, diameter .13. Length of hind tarsal segments, I .15; II .29. Rostrum extends beyond the cornicles. Length of rostral segments, III .25; IV .24; V .11. Diameter of cornicle base .45. Length of setae, on antenna .08, on hind tibia .07, on dorsum of abdomen .08.

Sensoria: On antennal segments, III, 0-1; IV, 1-2; V, 2-3; VI, 7. There are numerous small round sensoria on the hind tibia.

There are sixteen basal and two secondary subapical setae on antennal VI (Fig. 1, J).

Male

Alate.

Host

Larix laricina (DuRoi) Koch, on roots.

Holotype

Oviparous female, collected September 13, 1955, by V. B. Patterson at Gainford, Alberta. Type deposited in the Canadian National Collection, Ottawa.

This species differs from C. *spiculosa*, C. *lyallii*, and C. *laricifex* (Fitch) in possessing a longer rostrum, which extends beyond the cornicles instead of barely reaching the hind coxae, and finer, more numerous setae.

Cinara lyallii n. sp.

Apterous viviparous female

General colour dull black. Tibia with a short portion near the base light yellowish-brown, remainder dark brown. Antenna dark brown, except proximal portions of segments III, IV, and V which are lighter brown. Dorsum of metathorax and abdomen thickly covered with subcircular dark brown spots, each bearing a stout, acuminate seta. Muscle attachment plates moderately large (Fig. 1, K).

Measurements: Body length 4 mm., width 2.35. Width of head across eyes .91. Antenna, total length 1.70, segments, III .62; IV .26; V .38; VI .14 and .04. Hind tibia, length 2.80, diameter .11. Length of hind tarsal segments, I .16; II .40. Rostrum barely reaches hind coxae. Length of rostral segments, III .27; IV .23; V .09. Diameter of cornicle base .27. Length of setae, on antenna .06, on hind tibia .06, on dorsum of abdomen .07.

Sensoria: On antennal segments, III, 2-4; IV, 1-2; V, 2-3; VI, 7.

There are seven to twelve basal and four secondary subapical setae on antennal VI.

Oviparous female

General colour light ash-grey, speckled with black spots. Dorsum of metathorax and abdomen with numerous brown spots and setae, as in the apterous viviparous female. Lengths of rostral segments IV and V, hind tarsal segments, and setae, same as in the viviparous female; other measurements slightly smaller.

Sensoria: On antennal segments, III, 3; IV, 1; V, 2; VI, 7. There are numerous small round sensoria on the hind tibia.

Antennal VI bears nine to ten basal and three secondary subapical setae (Fig. 1, O).

Male

Apterous. Colour of body, hind tibia, antenna and markings on the dorsum, as in the apterous viviparous female.

Measurements: Length of body 2.32 mm. Width of head across eyes .70. Antenna, total length 1.37, segments, III .47; IV .21; V .30; VI .14 and .06. Hind tibia, length 1.60, diameter .07. Length of hind tarsal segments, I .12; II .29. Rostrum extends beyond the cornicles; length of segments, III .24; IV .17; V .07. Diameter of cornicle base .21. Length of setae, on antenna .03, on hind tibia .04, on dorsum of abdomen .04.

Sensoria: There are numerous small round sensoria on antennal segments III, IV, and V.

Antennal VI bears eight basal and three to five secondary subapical setae.

Host

Alpine larch, *Larix lyallii* Parl. Found on the twigs of the previous season's growth, adjacent to the current growth.

Holotype

Apterous viviparous female, collected August 31, 1955 at Highwood Pass, Kananaskis, Alberta, by the author. Type deposited in the Canadian National Collection, Ottawa.

This species resembles *C. laricifex* (Fitch), *C. laricis* (Hartig), and *C. spiculosa* in having a short rostrum, reaching only as far as the hind coxae, and short, stout, spine-like setae. It differs from *C. laricifex* in having numerous brown spots on the dorsum of the abdomen of the apterous females. It differs from *C. laricis* and *C. spiculosa* in that the spots on the dorsum are smaller and more numerous in *C. lyallii* than in the other two species. The setae on the abdominal spots, and also those on the head and thorax are not on raised, volcano-shaped bases in *C. lyallii* as they are in *C. laricis* and *C. spiculosa*.

Observations on the Biology of Utah Black Flies (Diptera: Simuliidae)[1]

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Introduction

During 1951 and 1952 a study was conducted on types of larval habitat, larval and adult feeding, cocoon spinning, the emergence process and oviposition of Utah black flies. Most of the work was concentrated at six stations in City Creek Canyon and four stations in Red Butte Canyon. The data obtained at these stations were supplemented with additional observations, made thru 1955, in various localities throughout the state.

Red Butte and City Creek Canyons are located on the western side of the Wasatch Mountains. Red Butte Canyon is directly east of Salt Lake City, and City Creek Canyon is approximately three miles northwest of Red Butte and north of the City.

City Creek descends from 7,300 feet to 4,500 feet in a distance of eleven miles, and has an average gradient of 250 feet per mile. The rate of fall is comparatively uniform. The stream is heavily shaded along most of its course. Most of the stream and its water-shed is the property of Salt Lake City, and has been closed to the general public since 1951.

Red Butte Creek is five and one half miles long and begins at an elevation of 7,000 feet. It drains an area of approximately 25 square miles, and has an average gradient of 364 feet per mile. This average figure does not present a true picture, as the stream flow tends to be accelerated in certain localities and retarded in others, due to the many beaver dams in the canyon. The stream is variably shaded; much of it is fully exposed to the sun while other sections are lightly or heavily shaded. In 1909 the United States War Department purchased the entire watershed in Red Butte Canyon. The canyon has been closed to public entry and has existed since 1909 under relatively natural conditions.

General Biology

Larval Habitat:

It is generally considered that black fly larvae prefer the parts of a stream with the most rapid flow, particularly where the water flows over stones, sticks, logs and other obstructions. Observations were made to determine the rheophily preferences of black fly larvae. The larvae of the simuliid species observed in this study were found in a wide range of rates of stream flow. They tended to concentrate in running water which flowed at rates below six feet per second. Larvae of *Simulium arcticum* Malloch, *S. vittatum* Zetterstedt and others have been found in water flowing at rates from 0.82 feet per second to 4.3 feet per second. *Simulium* sp. No. 73 has been found in water flowing from 0.82 to 5.5 feet per second. Wu (1930) found a minimum rate of flow of 0.56 feet per second for *S. vittatum* and *S. venustum* Say. Table I presents a list of the species found at each station in the two canyons with the minimum and maximum rates of flow in which larvae were found. This table also gives an indication as to which species may be found associated under similar environmental conditions.

In City Creek Canyon and Red Butte Canyon black fly larvae tend to congregate on the downstream sides of stones, logs, or other objects, or on the

TABLE I
Larval Current Preferences[2]

Station	Rate of flow		Species present
	Min.	Max.	
	(ft., sec.)		
City Creek: 1–2–3...............................	1.2	4.4	*Simulium* sp. No. 73
4	3.3	5.5	*Simulium* sp. No. 73
5	1.2	1.4	*Simulium arcticum* *Simulium* sp. No. 73
6	1.2	4.9	*Simulium* sp. No. 73
Red Butte: 1	1.2	3.7	*Simulium vittatum* *Simulium piperi* *Simulium tuberosum* *Simulium arcticum* *Simulium* sp. No. 73
2–3	0.82	1.8	*Simulium vittatum* *Simulium piperi* *Simulium tuberosum* *Simulium arcticum* *Simulium canadense* *Simulium hunteri* *Simulium* sp. No. 73 *Prosimulium exigens*
4	1.7	4.3	*Simulium vittatum* *Simulium arcticum* *Simulium canadense* *Prosimulium exigens*

[2]All current velocity measurements were taken at the immediate side of numerous individual black fly larvae by use of a pitot tube.

upper surface of leaves of aquatic vegetation. Most of the larvae found in Red Butte Canyon, especially in the swifter waters, occupied these positions, but often in the slower waters of less than 1.2 feet per second, larvae were found on the undersides of sticks and leaves. Possibly this was a mechanism to escape the sediments that tended to accumulate on the upper surfaces. On no occasion were larvae found on algae-covered rocks or sticks. In contrast larvae of the dominant species in City Creek, *Simulium* species No. 73, were often found to occupy positions on rocks covered principally by moss and algae of the genus *Vaucheria*. An alga of more distinct structure rather than a slimy mass gives larvae something solid on which to attach. The larvae of this species occupied the upper or downstream surface of the objects to which they were attached except when they were found attached to the horsetail, *Equisetum prealtum* Raf., in which case they were found hanging upside down on the undersides of the branches. This position was necessitated by the fact that the branches of the horsetail floated so close to the water surface that insufficient space was present for the larvae between the branches and the water surface.

Feeding Methods and Food of Larvae

Larval Simuliidae obtain their food by the use of a pair of large cephalic fans that strain food particles from the water. Osborn (1896) stated, "To

obtain these (food particles) the fan-like organs peculiar to these larvae create currents of water directed towards the mouth. Any small and floating matter drifted by the current of water into the vicinity of these fans is attracted by the ciliary motions of the component rays of the same, and thus reaches the space embraced by them, and they, bending over the mouth, direct the further motions of the particles. If of the proper kind they are eaten; otherwise they are expelled by a sudden opening or parting of the fans." He did not believe that the mouth-parts were adapted for biting off pieces from large or solid substances, but were constructed to catch and engulf small objects.

In the present study direct field observations of larval feeding methods under natural conditions were made with a long-arm sterescopic microscope. The larva took a position with the dorsal side towards the current and then twisted its body so that its anterior ventral portion was turned into the current. The current bends the larva so that the anterior end is downstream from the attached posterior end. The fans were spread and either held stationary until food particles were strained from the water, or were vibrated rapidly back and forth through the water as the body was turned from side to side. The fans, after straining particles of food, were brought forward and downward to the mouthparts.

Direct observations showed that the larvae obtained a certain amount of food by scraping the substratum to which they were attached. Larvae were observed to scrape a considerable area around their point of attachment. That these scrapings were ingested is supported by the fact that samples collected from around the points of larval attachment correspond to some of the material examined within the intestines of the larvae. This appears to be a normal method of augmenting the food supply, although Wu (1930) observing this behavior in the laboratory, attributed it to unfavorable conditions in standing water.

The present investigations indicate that the larvae in City Creek and Red Butte Canyons are largely herbivorous. The analyses of intestinal contents of larvae from these two streams are given in Table II. Elsewhere there have been several divergent accounts presented by different authors on the nature of the food consumed by black fly larvae. Some have reported that the larvae are mainly carnivorous, while others have considered them as largely herbivorous or omnivorous.

The color of the larvae varied according to the nature of the stream and the type of food ingested. Jobbins-Pomeroy (1916) also found this to be true. Larval color that resulted from food and other materials in the intestines, and not from pigments or colors in the body wall, varied from grass green to dark brown, according to the amounts of plant material and sand particles taken into the intestines. Larvae of the same species often showed considerable variation in color. The intensity of dark color in the larvae was proportional to the amounts of earthen particles ingested by the larvae. The larvae found in Red Butte Creek exhibited greater variations in color among specimens of the same species than did those of City Creek even though a greater variety of floating organic material was found in the latter. This variation was probably due in part to the greater amount of silt found in Red Butte Creek.

Samples of floating organic material were taken from City Creek and Red Butte Creek in an effort to determine the approximate amounts in each stream which might serve as part of the food supply for black fly larvae. One sample was taken from City Creek Canyon on August 7, 1952; another sample was taken from Red Butte Canyon on the same date. The samples were taken with

TABLE II
Food of the Black Fly Larvae

Larval attachment	Food identified from intestines of larvae		
	Diatomes	Other algae	Miscellaneous
CITY CREEK CANYON: Aquatic plant— *Equisetum prealtum*	*Diatoma hiemale var. mesodon* *Navicula* spp. (3 species) *Meridion circulare* *Tabellaria* sp. *Cocconeis* sp.	*Tribonema major* *Tribonema bombycinum* *Oscillatoria* sp.	Basidiomycetes Fungi (2 species) Spores of same *Hygroamblystegium riparium*—leaf fragments *Hygrohypnume* sp. —leaf fragments Moss rhizoids (numerous) Pitted vessel elements Spiral vessel elements
Alga covered rocks— *Vaucheria* sp.	*Diatoma hiemale* *Meridion circulare* *Gomphonema* sp. *Cocconeis* sp. *Tabellaria* sp. *Navicula* spp. (6 species) *Cymbella* sp.	*Oscillatoria* sp. *Chaetophora elegans* *Vaucheria* sp.	Basidiomycetes fungi—mycelium
RED BUTTE CANYON: Bare rocks—	*Diatoma* sp. *Fragilaria* sp. *Meridion* sp. *Gomphonema* sp.	*Spirogyra* (38–40%)	Moss leaf fragments Moss rhizoids Bits of decayed conifer wood
Aquatic plants— *Scirpus microcarpus* *Typha latifolia* *Carex inflata*	*Fragilaria* sp. *Tabellaria* sp. *Diatoma* sp.		Moss rhizoids Much sand

a plankton net which had a mouth opening nine and one-half inches in diameter. This net was submerged and left for a period of one hour. Large pieces of leaves and sticks were removed from the samples which were then centrifuged and volumetrically measured wet in the laboratory. The following measurements were obtained:

> Red Butte Creek
> 3.2 cc. of floating organic
>   material
> 1.2 cc. of sand
> City Creek
> 12.7 cc. of floating organic
>   material
> 1.0 cc. of sand

An average combined area measurement was made of the two larval fans of three mature larvae of *Simulium vittatum*. The average area of the fans was approximately 1.34 sq. mm. and varied slightly with the position and contour

of the larval fans. The measurements were taken while the fans were in a position believed to approximate the normal stationary position assumed in straining food particles from the water. It was determined that the average volume of the larval alimentary tract, based on the measurements of three mature larvae, was approximately 0.511 cu. mm.

It was determined that approximately 0.095 cu. mm. of available food passed through an area of 1.34 sq. mm. every hour in Red Butte Canyon and approximately 0.38 cu. mm. of available larval food passed through an area of 1.34 sq. mm. every hour in City Creek Canyon. The gut of larvae in Red Butte Creek could be expected to be filled in approximately five and one-half hours if all the organic matter were ingested. In City Creek the gut could be filled in approximately one and one-half hours. This seems to be an adequate food supply, especially in City Creek Canyon, as it often takes a day or more for larvae to clear the gut of food. Davies (1949) noted that it took more than a week for *Prosimulium hirtipes* Fries to empty the gut at 40°-50° F. The larvae, however, might not efficiently take all of the 0.095-0.38 cu. mm. of food per hour and the degree of this efficiency would be reflected by the growth rate and also in the amount of food scraped from the substrate. According to Davies the larvae can fill their guts by scraping and nibbling algae in 20-26 hours, sometimes less.

In order to obtain more valid results in a study such as this, refinements would be necessary, especially in the sampling technique. Also, samples should be taken over a period of time and analyzed statistically.

Cocoon Spinning:

Pupation occurs in nearly the same situation as does larval development, with larvae and pupae frequently being found together. Many larvae, when ready to pupate, move from their position on the upstream side of a rock or twig to a more protected site on the downstream side. They often move into cracks in rocks, or behind cocoons which afford some protection from the full force of the stream currents. The larvae of some species, e.g. *Simulium piperi* Dyar and Shannon, tend to migrate to slower water for pupation, while other species, eg. *S. arcticum*, pupate more frequently in the swifter waters.

Accounts of the process of cocoon spinning have been presented by several authors. Tonnoir (1923) fully described the process for *Austrosimulium tillyardi* Tonnoir, an Australian species whose cocoon is almost circular. Puri (1925) gave brief accounts for three British species, and Wu (1930) studied and described the process for *Simulium venustum*.

The following is an account of the cocoon spinning process of *S. vittatum* as observed by the writer in Red Butte Canyon on July 15, 1952. With the aid of a long-arm binocular microscope, which was set up directly over a group of larvae and pupae attached to a cattail leaf floating in the water, the writer was able to observe a larva prepare and spin its cocoon. The larva probed and searched about on the surface of the cattail leaf apparently seeking a suitable site for its cocoon. The period of probing averaged three minutes. These motions presumably are for the purpose of cleaning the substratum of debris, or testing the firmness of the substratum (Wu 1930).

When a suitable location was found, the larva began the task of spinning. The larva, after becoming firmly anchored, with its dorsal surface to the current, extended itself downstream as far as possible and placed a large loose mass of silk on the leaf. With a continuous thread another smaller mass of silk was laid down to the left side of the point of larval attachment. The thread was then moved to a spot directly in line with the downstream mass as far upstream

as the larva could reach. The thread was carried forward next to the right side of the larva and a similar mass was laid down opposite the point of larval attachment at the same level as the mass on the left side. A final thread connected this mass to the large downstream mass. Thus the larva encircled itself with a silken framework about which the rest of the cocoon was built.

After the framework was completed a loose network of silken threads was spun and attached repeatedly from side to side to the right and left downstream longitudinal threads of the frame. This was begun just anterior to the larval point of attachment and continued to the downstream mass of the frame. This formed a net-like structure just downstream to where the rim of the cocoon was to be located.

With the preliminaries completed the larva then strung a series of closely packed threads from one of the lateral masses upward and dorsally over its body to the similar mass on the opposite side. This series of threads composed the rim and thickest part of the cocoon. Working from the underside of the arch the larva strung a series of threads from the arch to the upstream mass of silk where they were attached closely together to form the upstream apex of the cocoon. From this point the larva worked forward to the rim spinning threads and attaching them from side to side connecting the right and left upstream longitudinal threads of the frame. The larva twisted and turned spinning silk from side to side and forward and backward, soon giving shape to the cocoon. When the cocoon was nearly completed the larva worked under the cocoon first along one side and then the other and added an inward projecting thin, flat mass of silk placed directly on the substrate along the length of the cocoon. This flattened mass of silk was slightly widened anteriorly. This put the finishing touches on and completed the main body of the cocoon.

When the main portion of the cocoon was completed the larva began the task of constructing the floor of the pupal case. · This was started at the upstream end and proceeded in a downstream direction. The larva worked back and forth and attached a loose network of threads between the apex of the cocoon and the inward projecting flattened mass from the two sides. This loose network extended downstream about one-quarter of the length of the cocoon. From this point on the larva made the floor thicker and of a tighter mesh. The threads were attached higher and higher up the sides of the case as the floor was continued downstream. The floor extended downstream (forward) a little over one-half the length of the cocoon. The larva did not change its position of attachment throughout the entire process. Wu (1930) stated that the floor of the cocoon of *Simulium venustum* was laid down before the cocoon was spun. However, for *S. vittatum* the floor was the last part of the cocoon to be completed.

The writer's observations agree with those of Wu (1930) in that the entire process takes from 40 to 60 minutes. This includes the time the larva occasionally ceases its work, probably for resting or renewing its silk supply. When the cocoon was finished the larva released its position and slowly turned around, orienting itself for the transformation from larva to pupa.

The cocoon spinning process also was observed for *S. canadense* Hearle and was essentially as described above. However, the rim of the cocoon was in the form of a complete circle and the floor of the cocoon was composed of a loose silken weave.

The writer was able to observe this process on several different occasions. The procedure varied little each time, except for one instance where the larva spun its cocoon in a vertical position on a twig. It was difficult to watch the

process in such a position, but it was essentially as described above, except for the fact that part of the cocoon was spun around the veinous network of a small portion of a dead leaf. This was the only observation where debris was incorporated into a cocoon.

On numerous occasions the writer has found the cocoon of one pupa partially built within an abandoned pupal case of the same species. The cocoons of smaller species such as *S. canadense* and *S. tuberosum* Lundstroem, often have been found almost entirely within a larger cocoon as of *S. vittatum* or *S. piperi*. The actual process of one larva constructing its cocoon within that of another has been observed several times.

Larvae also have been found to utilize an already constructed cocoon left by an emerged adult. In this case the larva does not spin its own cocoon, but undergoes the transformation within the adopted cocoon after closing off the entrance with silk, much as is done on the outset of the regular spinning process.

Metcalf (1932) stated, "The cocoon seems to serve more as a method of anchorage in the swift water than for protection." It seems logical, however, that the cocoon does provide protection, not only from the swift water, but from floating debris and sediments that might damage the pupa. It is probable also that it serves as some protection from possible predators.

Pupal Associates

On many occasions while collecting specimens in both City Creek and Red Butte Canyons, pupae were found that were almost completely covered by a light yellow, sticky, gelatin-like material. Often this material was found only on one side of the pupal cocoon. The removal of this substance revealed one or two small chironomid larvae. Some of these were found to be undetermined species of the genera *Corynoneura* (*Thienemanniella*), and *Hydrobaenus* (H.) (near *obumbrata* Johannsen, and near *novoriunda* Johannsen). Occasionally these jelly-like masses were found separately on rocks, but the majority of them were associated with several species of simuliid pupae.

Empty pupal cases were found that had the entrance sealed with this jelly-like material. Removal of this substance revealed one to three of the chironomid larvae. On numerous occasions, cocoons containing live pupae were found that had the cocoon entrance sealed with only the pupal filaments extending through. As many as two chironomid larvae were found inhabiting a single cocoon along with the black fly pupa. As far as could be determined these chironomid larvae did not prevent the successful emergence of the black fly adult.

Emergence:

The emergence of adult black flies from their pupal skins has been observed in the laboratory on numerous occasions. The emergence process is essentially as follows. A split, which extends along the mid-dorsal line from the anterior part of the pupal thorax toward the posterior end of the abdomen, occurs in the integument of the dorsum. Simultaneously a transverse split occurs across the tergum of the thorax. The resulting T-shaped aperture exposes the dorsum of the adult thorax. The front feet of the fly appears first through the aperture. The adult then slowly pulls itself forward, soon revealing the head. Many times the head may be freed first followed by the front legs. As soon as the head and fore legs are free the rest of the body is quickly pulled out from the pupal skin which is left partly out of the cocoon. The wings of the adult may expand as the body is pulled from the pupal skin. However, in many cases the wings are expanded after the adult has fully emerged. After the wings are expanded the fly remains motionless for a short period of time during which the integument

dries and becomes hardened.   The emergence process usually requires less than three minutes.

Pupae in moist rearing chambers often exhibit considerable movement. These movements, at times, are quite forceful.   This activity may continue for periods up to about one-half hour at a time with the pupa continually moving out of the cocoon for a short distance and then moving back into the cocoon.   The adult abdomen can be seen clearly through the pupal case and it exhibits much lateral as well as vertical movement.   The forward and backward movements might possibly serve as a "battering ram" action to aid in the rupture of the pupal skin. During this movement a bubble of gas can often be seen clearly, circulating from side to side within the dorsal part of the pupal thorax.   Jobbins-Pomeroy (1916) also observed this activity and stated, "Four or five hours before emergence there is a very noticeable intermittent movement of the adult within the pupal skin, which is gradually distended with air toward the anal extremity . . ."

On one occasion in the laboratory the author was examining a group of pupae in a pint jar of water, when a single newly emerged male of *S. vittatum* was noticed.   The pupal case was near the surface of the water, and as soon as the fly emerged it dived to the bottom of the jar, where it swam around the jar, in the absence of a surrounding gas bubble, in gradual ascending circles. This continued for nearly six minutes before the fly suddenly directed itself toward the surface of the water.   The fly then crawled onto a cattail leaf to expand its wings and dry.   The fly, after being placed in a small test tube on a piece of blotting paper, began to vibrate.   The vibrations were noticeable in the head region, especially in the antennae.   It was evident also in the halteres and abdomen.   The two hind legs were raised, the left one crossed under the uplifted abdomen to the opposite side where the two legs were used to stroke the right wing.   The stroking movements began near the wing base and continued to the tip of the wing.   It seems probable that the movement of the body fluids into the veins to unfold the wings was assisted by the stroking of the wings with the back legs.   When the right wing was expanded the left wing was stroked until it was completely expanded.   The fly attempted flight several times, but was unable to fly in the small glass tube.   This stroking of the wings with the back legs to aid wing expansion was observed many times in Ontario during the summer of 1955 for both *S. decorum* Walker and *S. vittatum*.

In the natural habitat emerging adults of *S. vittatum* in Utah were observed to take flight almost immediately upon reaching the surface of the water, but soon landed to rest and dry.   However, observations by the author during the summer of 1955 in Canada showed that many individuals of *S. vittatum* and *S. decorum* crawled out of the water onto rocks, sticks, and grass blades to expand and dry their wings before they were able to take flight.

Wu (1930), Coquillett (1898), Jobbins-Pomeroy (1916), and Cameron (1922) found the adult to take flight almost immediately upon reaching the surface of the water.   McBride (1870), Emery (1913), and others agreed that the black fly stayed on the surface of the water or held to some object to wait until the wings were dry before attempting flight.

The difference in opinion concerning the method of emergence may be due to differences between species or to variations within a species in different types of habitat.

In the field black flies were observed to emerge principally during the morning hours before 10.00 a.m. and again in the late afternoon and early evening hours.

Oviposition

A small swarm of ovipositing females of *Simulium arcticum* was observed on the morning of June 3, 1952 in Red Butte Canyon. The flies hovered and darted back and forth for short distances, always keeping within ten or twelve inches of the surface of the water. They chose to lay their eggs just below a short series of rapids where the water was deeper and the surface less disturbed. Roots from a nearby tree extended from the stream bank into the water about three or four inches below the water surface. One female under observation suddenly dived into the water at the side of a root, presumably deposited a series of eggs on the root, and about thirty seconds later emerged downstream approximately two feet from the point of her entry into the water. Several ovipositing females entering the water in a similar manner were washed downstream as they tried to emerge from the water. One female chose a water-splashed rock on which to lay her eggs. She continually lost her footing because of the water splashing on the rock and against her body. Even though the fly lost her footing, the abdomen remained attached to the place on the rock where she was depositing her eggs. After twelve eggs were deposited the fly attempted flight, but was stuck fast to her egg mass.

Upon examining the roots of the tree where the oviposition had occurred, it was noted that one root two feet in length had thirty egg masses on it. These masses varied in size, but the largest measured one-half inch in width by three-fourths inch in length and was about one-half inch in depth. The larger masses represented the oviposition of many female black flies. The eggs appeared to be laid in strings several layers deep. The fresh eggs appeared as milky-white masses on the roots while older egg masses varied from light tan to yellowish-brown. Black fly eggs turn darker with age. A number of females were found stuck to the gelatinous matrix of their egg mass. All of the eggs found were attached to the underside of the roots not more than three or four inches below the water surface. Cameron (1922) observed the oviposition habits of *S. arcticum* (as *S. simile* Malloch) and stated that, "the eggs are not laid singly but in large cake-like masses, . . ." Freeden et. al. (1951) conducted investigations on egg laying habits of *S. arcticum* and found that the eggs were apparently laid singly over the water and allowed to settle and become embedded in the sand on the bottom of the stream. Apparently oviposition in *S. arcticum* is similar to that of *S. decorum* and *S. vittatum* in that they have two distinct methods of oviposition (Davies and Peterson, in MS.), viz. by dropping eggs into the water while in flight and by depositing the eggs on some surface while landed.

Biting and Feeding Habits

Certain species of black flies can be very annoying and persistent pests of man. They fly in circles about the head region, darting into the corners of the eyes, into the ears, and into the nostrils. They find their way into most openings in the clothing which will allow their passage to the skin. Even though some species of black flies rarely or never bite man, they may, nevertheless be very pestiferous. While on a field trip in Red Butte Canyon in late August females of *Simulium vittatum* were so numerous and annoying that the author was forced to wear a head-net. This provided protection at first, but the flies soon found their way to the inside of the net in sufficient numbers to partly clog the nostrils. Despite the great numbers of flies the author did not receive a single bite. In the meadows and pastures of the Salt Lake Valley during warm days in late August and September this species can often be found flying about the head of man, rarely biting him, but readily biting near-by horses and cattle. It was observed by a number of investigators that black flies will bite only at certain

seasons and then only under conditions which are favorable. The factors which determine when the female will bite have been discussed by several authors, among which were Emery (1913), Jobbins-Pomeroy (1916), Rubtzov (1936), Baranov (1939), Underhill (1940, 1944) and more recently Davies (1952) and Dalmat (1955).

It has been reported that an increase of black fly feeding activity occurred during periods of falling barometric pressure (Rubtzov, 1936; Underhill, 1940, 1944; and Davies, 1952). The fact that barometric pressure influenced feeding was noted early in the present study. It was observed that species that attack man, *Cnephia mutata* Malloch, *Simulium arcticum*, *S. tuberosum*, *S. hunteri* Malloch, and *S. vittatum* rarely attempted to bite the author at lower altitudes, but when travelling above approximately 7,000 feet these species readily attacked, and were very bothersome.[3] *S. vittatum* bites freely at low altitudes but mainly attacks cattle and horses. However, on a single occasion the author was bitten by a female of *S. vittatum* at an elevation of 4,337 feet. This is the first record the writer has of this species biting man in Utah at an elevation below approximately 7,000 feet. In general the greatest period of activity at higher altitudes, approximately 7,000 to 11,000 feet, seems to be on warm partly-cloudy days. Black flies were found to be active on warm dark nights. The writer has spent several sleepless nights because of the all night vigilance of these pests. Thirty-nine flies of two genera and five species, *Cnephia mutata*, *Simulium arcticum*, *S. vittatum*, *Simulium sp.*, and *S. (Eusimulium)* sp., were collected during the course of a single dark July night from 8:00 P.M. to 6:30 A.M. at an elevation of 10,000 feet. In one instance the flies might have been attracted by a small fire which was kept burning during the night. The activity of these flies has been observed to continue throughout the night even during drizzling rains. In several instances the author has noted black flies to be active after it was dark, making it necessary to observe their activity by use of a flashlight. This was true of *S. decorum* and *S. vittatum* especially during periods of oviposition. Davies (1952) found that the activities of black flies changed little with light except at the extremes. He found that some flying, feeding and biting continued at light intensities as low as one foot candle.

The host preference of most of the species of black flies are not well known. A number of black fly species are known to bite man, horses, cattle, turkeys, ducks and other animals. Some species attack and feed on a variety of hosts. Davies and Peterson (in MS.) included host records for several species of Canadian black flies. In Utah two host records were recently obtained. Two specimens of *S. tuberosum* were taken from the Uinta ground squirrel, *Citellus armatus* Kennicott, and five specimens of the same species were taken from the golden-mantled ground squirrel, *Citellus lateralis* Say.

Another interesting biting record was noted by the author in Red Butte Canyon. A female black fly, *S. vittatum*, was taken with its mouthparts inserted into the abdomen of a black ant, *Formica fusca subaenescens* Emery. The fly's abdomen was distended from sucking the body fluids of the ant. Both were dead when found, but had been dead a short time.

Jobbins-Pomeroy (1916) gave reference to two accounts of black flies feeding upon animals other than mammals or birds. One was by Hagen (1883) who found a species of *Simulium* attacking and feeding upon the chrysalids of the butterfly *Neophasia menapia* Fleder. Hagen referred to this *Simulium* as

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[3]Davies suggested (in litt.) that absolute pressure may not be the important factor, although it cannot be ruled out. He suggested that this phenomenon may be due to different amounts of fat stored by the larvae. Those larvae that store little fat produce adults that are more apt to bite than those produced from larvae which store considerable quantities of fat. This would apply to individuals of any black fly species capable of biting regardless of their altitudinal location.

similar to the "New England Black Fly" but does not give the exact species. The other record noted by Jobbins-Pomeroy was by H. Pryer (1887) in Japan, who found species of the genus *Simulium* attacking the larva of a sphingid, *Smerinthus planus* Walk., and also the imago of *Stauropus persimitis* Butl. Emery (1913) cited a reference by F. V. Theobald (1892) which gave an account of Simuliidae feeding on maggots and caterpillars.

References

Baranov, N. 1939. Stand der Kolumbatscher muckenforschung in jugoslavien. *Ztschr. f. Parasitenk* 11:215-234.

Cameron, A. F. 1922. The morphology and biology of a canadian cattle-infesting black fly, *Simulium simile* Mall. (Diptera, Simuliidae). *Can. Dept. Agr. Bull.*, 5 (n.s.):1-26.

Coquillet, D. W. 1898. The buffalo-gnats, or black flies, of the United States. *U.S. Dept. Agr., Div. Ent. Bull.*, 10 (n.s.): 66-69.

Dalmat, H. T. 1955 The Black flies (Diptera, Simuliidae) of Guatemala and their role as vectors of onchocerciasis. Smithsonian Misc. coll. 125 (1):1-425.

Davies. D. M. 1949. The ecology and life history of blackflies (Simuliidae, Diptera) in Ontario with a description of a new species. Ph.D. Thesis. University of Toronto.
          1952. The population and activity of adult female blackflies in the vicinity of a stream in Algonquin Park, Ontario, *Can. Jour. Zool.* 30:287-321.
          1956. Personal communication.

Davies, D. M. and B. V. Peterson. Observations on the mating, feeding, ovarian development, and oviposition of adult black flies (Simuliidae, Diptera). In Manuscript.

Emery, W. T. 1913. Morphology and biology of *Simulium vittatum* and its distribution in Kansas. *Kansas University Sci. Bull.*, 8 (9):323-362.

Fredeen, F. J. H., Rempel, J. G., and A. P. Arnason. 1951. Egg-laying habits, overwintering stages, and life-cycle of *Simulium arcticum* Mall. (Diptera: Simuliidae). *Can. Ent.*, 83:73-76.

Jobbins-Pomeroy, A. W. 1916. Notes on five North American buffalo gnats of the genus *Simulium*. *U.S. Dept. Agr., Bur. Ent. Bull.*, 329:1-48.

McBride, S. J. 1870. The so-called web-worm of young trout. *Am. Ent. and Bot.* 2 (12): 365-366.

Metcalf, C. L. 1936. Black flies and other biting flies of the Adirondacks. *N.Y. State Mus. Bull.*, 289:5-58.

Osborn, H. 1896. (Simuliidae in) Insects affecting domestic animals. *U.S. Dept. Agr., Div. Ent. Bull.*, 5 (n.s.):31-58.

Puri, I. M. 1925. On the life history and structure of the early stages of Simuliidae (Diptera, Nematocera), Part I. *Parasitology* 17:295-334.

Rubtzov, I. A. 1936. Notes on the biology and ecology of blackflies (Simuliidae). In Russian with English summary. *Mag. Para. Inst. Zool. Acad-Sci. USSR* 6:169-200.

Tonnoir, A. L. Notes sur la biologie des larvaes de *Simulium* (Diptera). *Ann. Biol. Lac.*, 11:163-172.

Underhill, G. W. 1940. Some factors influencing feeding activity of simuliids in the field. *Jour. Econ. Ent.*, 33 (6): 915-917.

⸺ 1944. Black flies found feeding on turkeys in Virginia, (*Simulium nigroparvum* Twinn and *Simulium slossonae* Dyar and Shannon.) *Va. Agr. Exp. Sta. Bull.*, 94:1-32.

Wu, Y. F. 1930. A contribution to the biology of *Simulium* (Diptera). Papers Mich. Acad. Sci. Arts. and Letters, 13:543-599.

A Granulosis Virus Disease of the Western Grape Leaf Skeletonizer and its Transmission[1]

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Since 1950 the University of California has maintained a program designed to evaluate the effectiveness of certain insect parasites in the control of the western grape leaf skeletonizer, *Harrisina brillians* B. & McD., in San Diego County, California. During this time, all sustained efforts to produce parasites in quantities for field release have failed because of recurrent outbreaks of a disease of the skeletonizer larvae. The causative agent of this disease was identified by Steinhaus and Hughes (1952) as a granulosis virus.

From 1950 through 1953 all, or virtually all, of the domestic grapes in the infested area were kept under chemical treatment by the California State Department of Agriculture. In 1954 this chemical program against the skeletonizer within the infested area was restricted to a perimetrical band, while in 1955 it was dropped entirely. As a result of the above, parasite evaluation studies had, for the most part, been restricted to wild grape areas and to a 6.2-acre vineyard leased in 1953 and 1954 for experimental purposes. During the course of these studies it was observed that the only source of relatively disease-free moths was in the areas under chemical control, where insect parasites were virtually eliminated by cryolite dust. In the untreated areas, where parasite incidence gradually increased, the disease apparently was present everywhere, in low as well as in high host densities. Where host density was high the granulosis frequently became epizootic.

Another significant phenomenon was observed on many occasions in the wild grape areas. Heavy infestations died out completely after the colonies of young larvae had skeletonized small areas, each approximately one inch in diameter, of the leaves on which they had hatched. In a number of canyons where this was observed, there has been no reinfestation to date. Similarly, in the laboratory, extremely heavy mortality often immediately followed eclosion or took place during the first three larval stages.

These observations strongly indicate two possibilities: (1) that parasites are instrumental in transmission of the granulosis virus, and (2) that the disease is transmitted transovarially within the egg. Primarily, it was to test these two hypotheses that the experimentation described herein was initiated.

Symptoms of the Granulosis Virus

The external symptoms of the granulosis virus disease are rather obvious but vary with the stage of the insect. They include: (1) failure of eggs to hatch or of larvae to feed; (2) abnormal larval feeding; and (3) abnormal growth, coloration, and death of larvae.

Characteristic of the disease among newly hatched larvae is the occurrence of numerous caterpillars spinning down below a leaf or egg mass and dying while still suspended by silken strands. When the disease develops later, during the first three instars, it is most readily detected by abnormal feeding. Diseased larvae feed in a spotty manner, consuming tiny patches of the parenchyma tissue, usually on the under surface of the leaf, and giving the latter a "peppered" appearance. Healthy larvae, on the other hand, consume entire areas of the parenchyma tissue and produce a uniform skeletonization having a paperlike appearance. The spotty feeding of diseased larvae is followed by gradual cessation of feeding, dropping from the leaves, and death.

Food consumption by diseased fourth-and fifth-instar larvae is greatly reduced. Leaves are perforated with holes instead of being consumed entirely (except for the principal ribs), as is characteristic of feeding of healthy larvae. Feeding gradually ceases; the larvae become flaccid and shrunken to about half their normal size and change in color from lemon yellow through shades of grayish yellow to brown or black. Infected larvae are inclined to wander and usually become diarrhoeic, trailing behind them a brownish discharge. On drying, this discharge frequently fastens the moribund larvae to the leaves (Fig. 1). Most often, however, the larvae drop from the leaves and dry into a brittle mass.

Mortality resulting from the granulosis may occur in either prepupal or pupal stages, depending upon the time of infection, but it is especially prevalent in the former. In both cases the insect dries to a brittle black cadaver. Failure to escape from the cocoon is associated with moths developing from larval colonies in which disease was heavy. No gross symptoms of the granulosis have been detected definitely among emerged moths, although a wide variation in size observed in moths developing from lots of larvae in which the granulosis had been prevalent may reflect the influence of the disease.

The internal symptoms of the granulosis are equally characteristic. The gut of a diseased larva becomes opaque and lacks entirely the turgidity of that of a healthy larva. The principal site of infection of this disease, unlike that of previously described granuloses, is the mid-gut epithelium. Examination of this tissue in water mounts with either dark-field or phase-contrast microscope equipment reveals myriads of capsules emanating from the ruptured cells. Spherical vesicles containing rapidly vibrating capsules, such as those seen in other granuloses (Bergold, 1948), are of frequent occurrence. With the normal light-field illumination of the light microscope, capsules that have been freed from the ruptured epithelial cells are difficult to distinguish and impossible to identify with any degree of certainty. However, in cells which have not yet ruptured, but in which much of the cell contents has liquefied, the rapid Brownian movement of the capsules contained within the cell membrane is obvious with a light-field microscope. Many of these cells display the characteristic brown coloration commonly observed in other granulosis infections. Whole cells containing numerous capsules are seen very frequently in larvae in an advanced stage of this disease.

Although cells containing particles in Brownian movement are not uncommon in other types of pathology, these are not readily confused with cells containing capsules. A cell in which the contents have liquefied to the extent that particulate cell components can be seen moving within the cell membrane will exhibit a small number of visible particles which are not uniform in size. Many of these particles are noticeably larger than capsules, with a consequently less rapid motion. By contrast, cells filled with capsules in Brownian movement present an

Fig. 1. *Harrisina brillians* larva hanging from leaf after succumbing to virus disease. Length of larva ½ inch.

appearance of containing a very large number of rapidly moving particles of uniform size. The latter condition seems to be characteristic of this granulosis, and can be recognized readily with any type of light microscope.

Methods and Materials

In attempting to control the granulosis virus disease sufficiently to permit insect parasite production, sanitation measures were employed to as great an extent as possible. The eggs of *Harrisina brillians* were treated regularly with formaldehyde to minimize external contamination by the virus. The eggs proved to be remarkably resistant to formaldehyde treatment, for hatches up to 84 per cent were obtained after two hours immersion in 30 per cent formaldehyde by volume. Treatment with 40 per cent formaldehyde (commercial formalin) killed all eggs. No harmful effect resulted from two-hour immersion in 20 per cent formaldehyde—the time and concentration finally adopted for routine egg disinfection. Following each outbreak of disease, the entire laboratory was sprayed thoroughly with commercial formalin. These practices gave temporary relief from the disease, but it always reappeared—apparently as a result of reintroduction from outside the laboratory.

Larvae used in infectivity experiments were reared from disinfected eggs of moths considered to be disease free. Egg masses were divided so that larvae from different moths would be represented in about equal numbers in the infected replicates and in the controls. Larvae were infected *per os* by feeding on leaves dipped in a virus suspension (filtrate from 100 diseased larvae ground in 250 ml. of water).

In the parasite transmission tests, the same host stock and precautions as those described above were employed. The parasites were permitted to walk on virus-contaminated surfaces prior to confinement with host larvae. Honey, used as food for the parasites, was streaked around the host colonies to attract the parasites and thus effect maximum contamination of the leaves upon which the larvae were feeding. After confinement for 48 hours in large cages with one or the other of the parasite species, host larvae were reared in groups of six or seven in pint ice-cream cartons. Larvae used in the controls and kept free of parasites were transferred at the same time and reared in the same way—eight to ten per carton. Daily records on each larva were maintained until parasite or moth emergence, or until larvae showed definite external disease symptoms or it was otherwise certain that pupation would not occur.

Since only light-field microscope equipment was available in the laboratory at La Mesa, California, when the diagnoses were made, the appearance of rapidly moving capsules within cells or spherical vesicles was found to be the most dependable criterion for diagnosis. Numerous examples were observed in all stages except pupae and adults. Conversely, none were found in the hundreds of healthy specimens that were examined.

The light-field microscope observations were checked subsequently with those of phase-contrast equipment. In general, the latter equipment supported and made more obvious the phenomena that had been observed with the light-field microscope. This was particularly true of recognition of capsules contained in intact cells. It was found, however, that in cases in which the cells had ruptured, capsules free in the medium could be recognized quite readily with the phase-contrast microscope, whereas with light-field equipment this condition was usually overlooked. Thus it became evident that many instances of virus-caused mortality were undoubtedly recorded as negative in the original diagnoses.

Samples from some of the insects for which a positive diagnosis had been made with both types of light microscope were further checked with the electron microscope. Recognition of capsules with the latter instrument confirmed the identity of the particles visible with both light-field and phase-contrast micro-scopes.

Infectivity Tests

In the course of the studies on *Harrisina brillians* in the field, the length of time required for the disease to cause mortality became important in the interpre-tation of results. Preliminary experimentation by C. G. Thompson and A. R. Logan (unpublished report) indicated that the average time from infection to death was about 21 days. Heavy mortality in their controls, however, impaired the value of their data. Moreover, subsequent field and laboratory observations suggested a shorter incubation period. In order to obtain more adequate determinations, additional laboratory tests were conducted at average temper-atures of approximately 24°C (extremes 20° and 32°C).

In a preliminary test using third-instar larvae, all infected insects became moribund within 12 days. The gut epithelium of these insects was then examined for presence of the characteristic Brownian movement of particles within cell walls. Each of the 46 infected larvae indicated presence of the virus. In contrast, there was no larval mortality in the 50 control insects: 45 moths emerged, while 5, although fully developed, failed to escape from the cocoon.

The results of further infectivity tests, in which third-and first-instar larvae were compared, are shown in Table I. In this experiment the gut epithelium

TABLE I

Incubation period of the granulosis when developing in different instars
of *Harrisina brillians* larvae

Larval stage	Treatment	No. of replicates	Total larvae	No. of larval days until				Average time to mortality in days
				Feeding stopped	First mortality	50% Mortality	100% Mortality	
Third-instar	Infected	10	120	5–8	6	6.9	12	7.88
	Control[1]	10	60	—	None	—	—	—
First-instar	Infected	10	88	9–19	9	16.5	31	17.15
	Control[2]	10	90	—	13[2]	—	—	—

[1]Sixty moths emerged.

[2]Eighty-five moths emerged, three failed to escape from the cocoon, and two larvae died (gut examined and proved negative for virus).

of the infected larvae was not examined. Instead, daily mortality records were kept, which for the controls, continued until complete emergence of the moths, a period of 73 days.

It is of interest that the disease progressed to mortality at a considerably more rapid rate in third-instar larvae than in first-instar larvae. A variable in experimental procedure might account for this difference. The larvae of the third instar had no food other than virus-contaminated leaves. Conversely, the first-instar larvae were offered contaminated leaves for a period of four days only, beginning when they were three days old. After this they were transferred to clean leaves. The first-instar larvae molted during the period of confinement with contaminated leaves, so that the actual time of active feeding on treated leaves was little over two days. Inasmuch as the concentration of virus used for infection was only roughly calibrated and experimental data on the dosage required to initiate this disease are completely lacking, one can only guess as to the importance of the different feeding times involved. As a result of experience with other virus diseases, however, the authors are inclined to think that the initial dosage was sufficiently high to make later feedings of the larvae, whether on contaminated or uncontaminated foliage, unimportant. Moreover, the distribution of mortality indicated in Table I suggests that the larvae of the third instar of *Harrisina brillians* may be more susceptible to the granulosis than those of the first instar.

Insect Parasites as Transmitters of the Granulosis Virus

Field observations had shown an apparent correlation between outbreaks of the granulosis and the presence of *Sturmia harrisinae* Coq. and *Apanteles harrisinae* Mues., the two major insect parasites of the skeletonizer. In the laboratory, in the absence of these parasites, the disease frequently did not appear, especially when larvae from healthy stock were reared at low density (5 to 12 per container) from disinfected eggs. It was not unusual for moths to develop from all the larvae of controls of this type. Conversely, where genetically similar larvae were exposed to parasitization by either of the above parasites prior to low-density confinement, mortality from causes other than known parasitization ranged up to 20 per cent.

Dissection of larvae moribund from "unknown cause" often revealed the presence of dead larvae of either *Sturmia* or *Apanteles*, together with indications

of virus infection. In a few instances evidence of virus disease was found in host larvae from which *Apanteles* had emerged. Mechanical transmission of the virus by both of the parasites was thus indicated. Thompson and Steinhaus (1950) concluded that *Apanteles medicaginis* Mues. serves as a probable transmitter of the polyhedrosis of the alfalfa caterpillar, *Colias philodice eurytheme* Bdvl., and their data indicated that the mode of transmission was by the contaminated ovipositor. To test further the hypothesis that *Sturmia* and *Apanteles* transmit the granulosis virus of the skeletonizer, additional laboratory experiments were conducted. Results are shown in Table II.

TABLE II

Transmission of granulosis to larvae of *Harrisina brillians* by the parasites
Apanteles harrisinae and *Sturmia harrisinae* in laboratory tests

Parasitization	Number of larvae tested	Larvae from which adult moths emerged	Larvae from which parasites emerged	Dead or moribund larvae from which no parasites emerged		
				Total Number	Examined microscopically	
					Number	Per cent virus-positive
None (control).........	181	172	0	9	9	0
A. harrisinae..........	210	55	114	41	16	25
S. harrisinae..........	130	35	71	24	13	38.5

The data presented might have been more conclusive if all the moribund larvae of the parasite trials had been examined, as was true of the control; and if positive diagnosis had not been limited to detection of Brownian movement of the capsules within cell walls. If it had been possible at the time the diagnosis were made to recognize the presence of capsules which were no longer contained in the cells, it is evident that the percentages given in Table II would have been considerably higher.

Larval mortality was significantly higher in the parasite trials than in the controls. It cannot be stated positively, however, that this difference resulted only from the virus. Vegetative and spore-forming hyphae and oval spores of an unidentified fungus were found in the body cavity of a few of the larvae of the parasite trials; although these were probably saprophytes, the possibility that they could have contributed to mortality should not be overlooked. Super-parasitism and other mechanical effects of parasitism also could contribute to mortality in the parasite trials. Nevertheless, the data indicate a correlation between the presence of the virus and the presence of the insect parasites, with the implication that both *Apanteles* and *Sturmia* may transmit the disease.

In the field the parasites are most likely contaminated by walking on leaves smeared with diarrhoeic discharges of the diseased larvae. From this experiment as well as from field observations, it seems probable that both *Apanteles harrisinae* and *Sturmia harrisinae* are instrumental in establishing foci of infection from which the disease may spread by other means. It is logical, further, to assume that any arthropods which move about the grape leaves, such as predators and ants, may perform a similar mechanical function. Rain and wind may also contribute toward dissemination of the virus.

Transovarial Transmission

Light microscope evidence.—The observation that the virus capsules within the cells of the gut epithelium could be detected readily by light microscope was first made in full-grown larvae of *Harrisina brilliams*. This was followed by examination of apparently diseased prepupae and larvae in each of the earlier stages, whereupon it was found that the presence of virus could be detected with equal clarity in all larval instars of the host. First appearing in larvae before external disease symptoms develop, the capsules become more evident with the approach of a moribund state.

The larvae which hang from the leaf by silken strands soon after hatching—a phenomenon which had long been a puzzle—were next examined and found to contain the virus. Larvae at the beginning of eclosion, with only their mandibles protruding through the egg chorion, were then examined and proved to be positive for virus. Following this, eggs which had been disinfected externally by immersion in 20 per cent formaldehyde for two hours were examined. These eggs had failed to hatch, but the choria were intact and the embryos inside were alive. Examination of the embryos revealed the presence of capsules in cells of the gut epithelia.

Although transmission of insect viruses from one generation to the next is frequently assumed to take place by way of the contents of the egg, there has been no positive demonstration of this phenomenon. Paillot (1926) demonstrated the presence of polyhedra in the tissues of adult moths of the silkworm, and subsequently (1930) believed himself able to demonstrate the presence of virus in unhatched silkworm eggs. In at least the latter instance, there is some room for doubt. Thompson and Steinhaus (1950) found that when eggs from contaminated adult *Colias philodice eurytheme* Bdvl. were treated with formaldehyde to disinfect the egg surfaces, the incidence of virus disease in the resulting larvae was greatly reduced but was not completely eliminated. It may be assumed that the small amount of virus disease appearing in these larvae resulted from virus carried within the eggs. Other examples could be cited, equally indicative of the probable truth of the thesis that insect viruses may be transmitted from one generation to the next internally in the eggs, and equally lacking is a positive experimental demonstration of the fact.

Electron microscope evidence.—In the hope of finding more definite information on this possible mechanism of virus transmission, various stages of the life cycle of *Harrisina brilliams* were examined with an electron microscope. The principal hope for success in this approach rests in the fact that the virus capsules of the granuloses have a fairly distinctive appearance when seen with the electron microscope. Their size, shape, and high degree of opacity to the electron beam combine to make recognition of them fairly definite when they occur in any concentration.

Eggs laid by contaminated adults were first examined. These were washed repeatedly, with vigorous agitation, in an effort to remove any capsules that might be adhering to the surfaces. The eggs were then ground in distilled water, and the resulting suspension was examined with the electron microscope. A few objects having the size and general appearance of capsules were detected. They were in such low concentration that one had to search to find an occasional specimen. Since it is difficult to be very sure of the identity of such objects at extremely low concentrations, an attempt was made to purify and concentrate them by centrifugation. The presence, in high concentrations, of other heavy components in the egg extracts made such attempts fruitless.

Very young larvae, one to three days of age, of an entire colony found suspended from the leaves, were next examined. These, like the eggs, were ground in distilled water. Unmistakable virus capsules in high concentration were found in these specimens.

Pupae, also, were examined in the course of this investigation. In many other insect virus diseases the presence of virus in pupae is well known, but in this disease it had not been clearly established. A group of pupae which appeared healthy, but which came from a rearing of larvae which had shown a high incidence of granulosis, was examined with the electron microscope and found to contain numerous virus capsules.

The adult tissue which it seemed most pertinent to examine was the female reproductive system, particularly the unlaid eggs. Consequently, the ovarioles, with the developing eggs contained in them, were dissected from moths emerging from various lots of diseased larvae, fixed in osmic acid, and sectioned at a thickness of approximately 0.05 micron. A thorough examination of these sections with the electron microscope preduced no conclusive evidence. Some of the eggs were found to contain objects which were similar to capsules in appearance but were not quite identical. These objects, which probably represented a normal component of the egg at a certain stage of its development, exhibited the same high opacity to the electron beam that is characteristic of capsules, but had a somewhat larger average size and a greater tendency toward a spherical shape than capsules exhibit. The ranges of size and shape, however, overlapped those of capsules in such a way that while it is possible to say that most of the particles seen certainly were not capsules, it is impossible to say that there were not capsules among them.

The evidence for generation-to-generation transmission of the granulosis virus internally in the egg is, in this work as in other studies of insect virus diseases, strongly indicative but hardly conclusive. Capsules can be found in larvae of all stages, including some that had died within three days after hatching, and can be demonstrated in pupae. Attempts to find capsules in the ovarian eggs of adult moths failed to produce either clearly negative or clearly positive results. The presence of capsules in unhatched eggs is strongly indicated, but there remains a reasonable doubt as to the identity of the particles seen.

Summary

A granulosis virus disease of the western grape leaf skeletonizer, *Harrisina brillians* B. & McD., was studied. The major insect parasites of the skeletonizer, *Apanteles harrisinae* Mues. and *Sturmia harrisinae* Coq., are indicated as having a role in the mechanical transmission of the granulosis virus. Infectivity tests showed that third-instar skeletonizer larvae are more susceptible to the disease than are first-instar larvae, although heavy mortality may occur in any immature stage. The principal site of infection in the larvae is the midgut epithelium.

By means of electron microscopy, virus capsules were demonstrated in all stages of the host except the egg and adult. The possible presence of capsules was indicated in the excepted stages. Light microscope examination gave strongly supporting evidence of virus capsules within embryos of intact eggs.

References

Bergold, G. 1948. Uber die Kapselvirus-Krankheit. Z. f. *Naturforschg.* 3b: 338-342.

Paillot, A. 1926. Existence de la grasserie chez les papillons de ver à soie. *Acad. d'Agr. de France, Compt. Rend.* 12: 201-204.

Paillot, A. 1930. Traité des maladies du ver à soie. G. Doin et Cie, Paris. 279 pp.

Steinhaus, E. A., and K. M. Hughes. 1952. A granulosis of the western grape leaf skeletonizer. *J. Econ. Ent.* 45: 744-745.

Thompson, C. G., and E. A. Steinhaus. 1950. Further tests using a polyhedrosis virus to control the alfalfa caterpillar. *Hilgardia* 19: 411-445.

Note on the Leaf Miner *Lithocolletis malimalifoliella* Braun (Lepidoptera: Gracillariidae) as an Apple Pest in Quebec[1]

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In 1953, 1954, and 1955 a species of leaf miner heavily infested leaves of apple trees in an orchard at Farnham, Que., causing severe damage to the crop. The pest was present on all apple varieties but was particularly abundant on Cortland. This infestation is apparently the first known to cause serious injury in Quebec.

Specimens were determined by Dr. T. N. Freeman, Entomology Division, Ottawa, as of *Lithocolletis malimalifoliella* Braun. This pest has not been previously reported from the Province of Quebec. It has been reported as a persistent and sometimes serious pest of apple in the Annapolis Valley, N.S. (Cameron and Patterson, 1941; Patterson and Neary, 1943), but does not appear to have been reported elsewhere in Canada. Under Quebec conditions *L. malimalifoliella* has two complete generations and a partial third per year and overwinters in the pupal stage. A survey revealed the pest to be present in all major apple-growing areas of the province.

Random samples of 1,200 mines showed parasitization of pupae by a braconid parasite to be 40 per cent in 1954 and 45 per cent in 1955. Specimens of the parasite were determined by Dr. W. R. M. Mason, Entomology Division, Ottawa, as of *Apanteles ornigis* Weed. This is apparently the first record of *A. ornigis* as a parasite of *L. malimalifoliella* in Canada (cf. Thompson, 1946; Muesbeck *et al.*, 1951).

References

Cameron, J. M. and N. A. Patterson. 1941. Insects of the season 1940 in Nova Scotia. *In* The Canadian Insect Pest Review 19, pp. 15-18. Canada Dept. Agr., Ottawa. (processed)

Muesebeck, C. F. W., K. V. Krombein, H. K. Townes, and others. 1951. Hymenoptera of America north of Mexico. Synoptic catalog. *U.S. Dept. Agr., Agr. Monogr.* No. 2.

Patterson, N. A., and M. E. Neary. 1943. Insects of the season 1942 in Nova Scotia. *In* The Canadian Insect Pest Review 21, pp. 14-18. Canada Dept. Agr., Ottawa. (processed)

Thompson, W. R. 1946. A catalogue of the parasites and predators of insect pests. Section 1, parasite host catalogue. Part 8, parasites of the Lepidoptera. *Imp. Agr. Bur., Parasite Serv.*, Belleville, Ont., Canada. (processed)

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Investigations Concerning Overwintering of House Flies in Manitoba[1]

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Introduction

The purpose of the following investigation was to determine whether house flies overwinter under Manitoba winter conditions, and if so by what means. The overwintering problem is particularly interesting and important in areas with a severe winter climate such as that of Manitoba. Solving this problem would shed information as to the cold resistance and winter adaptations of this insect. It could also become an important factor in controlling this pest. ·By disinfecting overwintering sites the nuclei of next year's house fly population would be reduced. This in turn might retard the attainment of the high house fly population level during the following summer.

Several investigations into this problem have been made by earlier workers in other parts of the world. However, the results are mostly contradictory or not applicable to this area. Hewitt (1912) and several workers cited by West (1951) claimed that house flies overwinter by hibernation. Hewitt (1912) believed that adults go into complete hibernation and that immature stages are not likely to overwinter. Of the other workers, some believed that adults hibernate and others claimed that only the pupae hibernate. No proof as to the validity of these claims was offered. Bishopp *et al* (1915), Dove (1916) and Matthyse (1945) suggested that the immature stages are largely responsible for the survival of the species through the winter. They believed that continuous breeding in suitable sites is a very important mode of overwintering.

Winter Observations in Dairy and Swine Barns

Observations on overwintering house flies were made in the swine and dairy barns at the University of Manitoba during the winters of 1953-54-55. Animals were kept in these barns all winter and both barns were heated, the temperature ranging from about 55°F. to 70°F.

House flies bred continuously in the swine barn during the winter. Maggots were found in vacant feeding troughs where the remains of swine feed still persisted, between the wall and feeding troughs where manure and feed had been scattered by the hogs, under the troughs and in the manure on the floor. Pupae were mostly found in dry manure and straw that accumulated under the feeding troughs. Maggots and pupae were found developing at temperatures ranging from 48°F. to about 90°F.

The majority of the adult house flies concentrated in the central part of the barn where the temperature was highest and no drafts occurred when the barn doors were opened. Pens containing suckling pigs were particularly attractive to the adults.

During the winter of 1954-55 a large unheated dairy and swine barn near Fort Whyte, Manitoba, were kept under observation for house fly activity. About 90 head of cattle were kept in the dairy barn and in the swine barn about 300 hogs were penned. These barns were very heavily infested during the summer and late in autumn. Adult house flies were active in both barns until the end of December. The temperature in these barns varied from about 50°F.

during the day to about 70°F. during the night and early part of the morning. During visits to these barns in January and February no adult house flies were observed. The barns were very damp during this period and possibly this might have inhibited flight by any adults present. No search was made for immature stages of the house fly.

These barns were again visited during the last week in April, 1955. Many adult house flies were observed flying in the barns. The weather prior to the visit was warm for about two weeks. The mean maximum temperature reached was 56.7°F., the mean minimum was 38.0°F. and the mean temperature for April was 47.0°F.

Since the temperature was too low for adult migration or long range flight, these flies must have overwintered in the barns, either by hibernating or by continuous breeding. It is very doubtful that adult hibernation occurred in the barn because the environment was extremely damp and conducive to fungus growth. Of the numerous dead adult flies that were examined, the majority showed unmistakable signs of fungus disease. Regardless of the mode of over-wintering, circumstantial but convincing evidence was obtained that house flies can overwinter in suitable unheated barns in Manitoba.

Cold Resistance of the Immature Life Stages of the House Fly

The cold resistance of the egg, larval, and pupal stages of the house fly was studied. The work was done in a constant temperature cold room maintained at 40°F.

Materials and Methods

About 100 newly-laid eggs were placed on wet blotting paper in separate dishes. These dishes were placed in the cold room and one dish was removed to room temperature every 24 hours. The eggs were left in the dish for another 24 hours at room temperature and then the hatched maggots were counted.

Larvae were placed in the cold room in the same medium in which they had developed. A number of larvae was removed from the cold room at about weekly intervals and put in fresh medium at room temperature. The numbers of maggots that survived and pupated, and the numbers of adults that emerged from these pupae were recorded. Newly-hatched larvae, half-grown larvae and fully developed larvae were used in the test.

Pupae were also placed in the cold room in the same medium in which they had pupated. At weekly intervals a number of pupae was removed from the cold room and placed in emergence cages at room temperature. The number of adults that emerged was observed.

Results and Discussion

1. Egg Stage:—At 40°F. and in a saturated atmosphere, the maximum survival of house fly eggs was 96 to 120 hours or three to four days (Table I). The greatest mortality occurred after the third day. No hatching was observed in the cold room. One dish containing several hundred eggs was removed to room temperature after four days in the cold room, kept there for ten days, but no hatching occurred and the eggs were assumed to be dead. In a control test at 80°F., 94 per cent of the eggs were viable.

2. Larval Stage:—Larvae survived considerably longer than eggs at 40°F. (Table II). Table II summarizes the results obtained from a test which involved larvae of all ages. Larval survival was determined by the number of larvae that formed normal pupae at room temperature after they had been removed from the cold room. In other tests, newly hatched larvae survived for nine days, half-grown larvae survived for 15 days and full grown larvae survived for 23 days in the cold room.

TABLE I
Survival of House Fly Eggs at 40°F.

No. of eggs removed from cold room	No. of hours at 40°F.	No. hatched at 80°F.	% hatched
90	24	82	91
120	48	104	85
52	72	30	57
76	96	2	2.7
114	120	–	–
156	144	–	–

No apparent growth of the younger larvae occurred at 40°F. None of the fully developed larvae formed normal pupae in the cold. After about ten days in the cold, the fully developed larvae began to form abnormal pupae. These had the shape of the larva but the hard puparium of the pupa. As the time in the cold increased, more of these abnormal pupae formed, none of which produced adults.

After about one week in the cold some of the larvae of all ages became spotted. These maggots were alive and active in the cold but when they were removed to a warm room, their bodies turned brown, then black and the insects died very shortly. Towards the end of the survival period, it was observed that many normal, apparently healthy and active cold larvae, when removed to a warm temperature, immediately turned brown and died in a few hours.

The full grown larvae were considerably more active in the cold room than the younger larvae. When they were exposed to light many of the older larvae burrowed into the medium, and some were even capable of crawling when placed on paper in light in the cold room. Most of the younger maggots were completely immobile and inactive in the cold. A few moved the anterior part of their body but the majority merely contracted and remained still.

3. Pupal Stage:—Survival of pupae was based on the number of adults that emerged when the pupae were removed to room temperature. Pupae were the most cold resistant of the stages studied at 40°F. (Table III). Complete mortality did not occur until the pupae were in the cold for about seven weeks.

It is doubtful that the mortality was due to desiccation because in the course of the test many pupae were examined and very few were dry. After about seven weeks in the cold room, most of the pupal cases contained only rotted bodies.

No emergence of adults occurred in the cold room. Toward the end of the survival period, adults had considerable difficulty in freeing themselves from the pupal cases when the pupae were removed from the cold. Often only the anterior part of the adult body emerged and the abdomen remained in the case.

TABLE II
Survival of House Fly Larvae at 40°F.

No. of larvae removed from cold room	No. of days at 40°F.	No. of normal pupae formed	% normal pupae	No. of adults emerged from pupae
100	11	60	60	32
100	14	44	44	16
100	4	–	–	–
100	22	–	–	–
200	29	–	–	–

TABLE III
Survival of House Fly Pupae at 40°F.

No. of pupae removed from cold room	No. of days at 40°F.	No. of adults emerged at 75°F.	% emergence
92	8	65	70.6
30	15	8	26.6
25	20	3	12.0
100	30	3	3.0
100	39	3	3.0
100	45	1	1.0
200	51	–	–

The insect unable to free itself, died in a few hours. Many adults that emerged successfully died in a few hours, although food and water were provided.

Conclusions

The results from this investigation, although preliminary and at most indicative only, and from previous work by other authors indicate that none of the stages of the house fly are adapted for survival at moderately cold temperatures. In spite of this, other observations indicate that house flies can survive the severe Manitoba winters by taking shelter in well constructed barns where they over-winter by hibernation or constant breeding.

Undoubtedly not every farmstead or barn will be favorable for house fly overwintering. Certain favorable barns will serve as loci for fly breeding and from which fly populations disperse to other farms during the summer. If these centres of infestation are disinfected before the flies leave the barn the fly population in a community may be lowered. This aspect of house fly control seems to have been overlooked and yet perhaps may be the most efficient and inexpensive method of fly control within a farm community.

Summary

Observations made during the winters of 1953-54 and 1954-55 provided evidence that house flies breed continuously through the winter in heated dairy and swine barns in Manitoba. House flies were also able to survive through the winter in an unheated dairy and swine barn near Fort Whyte, Manitoba, where the animals were penned all winter.

Cold resistance of the egg, larval and pupal stages of the house fly was studied at 40°F. Eggs survived for four days in the cold. Larval survival varied from nine to 23 days increasing with age. Pupae were the most cold resistant, surviving for about 45 days. No larval growth occurred in the cold room nor did any adults emerge from the pupal stage.

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References

Bishopp, F. C., W. E. Dove and D. C. Parman. 1915. Notes on certain points of economic importance in the biology of the house fly. *Jour. Econ. Ent.* 8: 54-71.

Dove, W. E. 1916. Some notes concerning overwintering of the house fly, *Musca domestica*, at Dallas, Texas. *Jour. Econ. Ent.* 30: 528-38.

Hewitt, C. G. 1912. House flies and how they spread disease. Cambridge University Press, London.

Hewitt, C. G. 1915. Notes on the pupation of the house fly (*Musca domestica*) and its mode of overwintering. *Canad. Ent.* 47: 73-78.

Matthyse, J. G. 1945. Observations on house fly overwintering. *Jour. Econ. Ent.* 38: 493-4.

West, L. S. 1951. The housefly. Comstock Publishing Co. Inc., Ithaca, New York.

Differences in Susceptibility of Two Species of Chrysopa (Neuroptera: Chrysopidae) to DDT[1]

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Since 1949 it has been noticed in a number of peach orchards in the Niagara Peninsula that the larvae of *Chrysopa plorabunda* Fitch are highly resistant to DDT, whereas those of *C. rufilabris* Burm. are susceptible. Data obtained in a representative orchard since 1953 are summarized in Table I.

TABLE I

Numbers of Larvae of *Chrysopa rufilabris* and *C. plorabunda*
Collected in Non-Insecticide and DDT Plots in Peach Orchard, 1953–55

Year	No. of samplings (80 trees each)	DDT plot		Non-insecticide plot	
		rufilabris	*plorabunda*	*rufilabris*	*plorabunda*
1953...............	3	0	39	40	57
1954...............	8	2	107	72	77
1955...............	3	0	196	22	272

Two 60- to 70-tree plots were sprayed with wettable sulphur or captan according to standard commercial schedules. Two adjacent plots were similarly treated with wettable sulphur and also with two applications of 50 per cent wettable DDT powder at 2 pounds per 100 gallons about 10 days apart in early July. Forty trees in each plot were sampled the same days at irregular intervals each season by brushing. This method, described elsewhere (Putman, 1955), is not a very efficient way of collecting chrysopid larvae because they are not easily dislodged from the foliage, but the numbers collected should be proportional to the actual populations. As sampling in this and in three other orchards showed that neither fungicide had any obvious effect on chrysopids, the two fungicide plots were considered as a single non-insecticide plot and the two DDT plots were similarly combined. Each value in the table represents the total number of larvae collected in each pair of plots in three to eight samplings during July and August after the first application of DDT.

During four of the five seasons from 1931 to 1935, *C. rufilabris* was more abundant than *C. plorabunda* in local peach orchards (Putman, 1937). Since at least 1950 their relative status has been reversed, and *C. plorabunda* is now the more abundant even in unsprayed orchards. General spraying of most vegetation with DDT in this intensive fruit-growing district has probably led to a widespread reduction of *C. rufilabris*.

References

Putman, W. L. 1937. Biological notes on the Chrysopidae. *Canadian J. Res.*, D, 15: 29-37.

Putman, W. L. 1955. Bionomics of *Stethorus punctillum* Weise (Coleoptera: Coccinellidae) in Ontario. *Canadian Ent.* 87: 9-33.

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